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SEP 78 J W BILLHEIMER, G FONDAHL, A W SIMPSON DCPA01-76-C-0317
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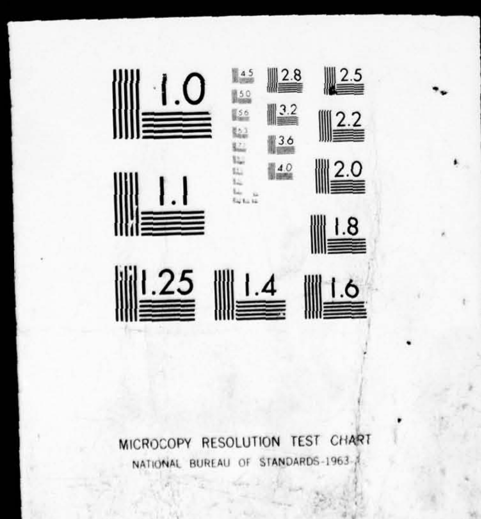
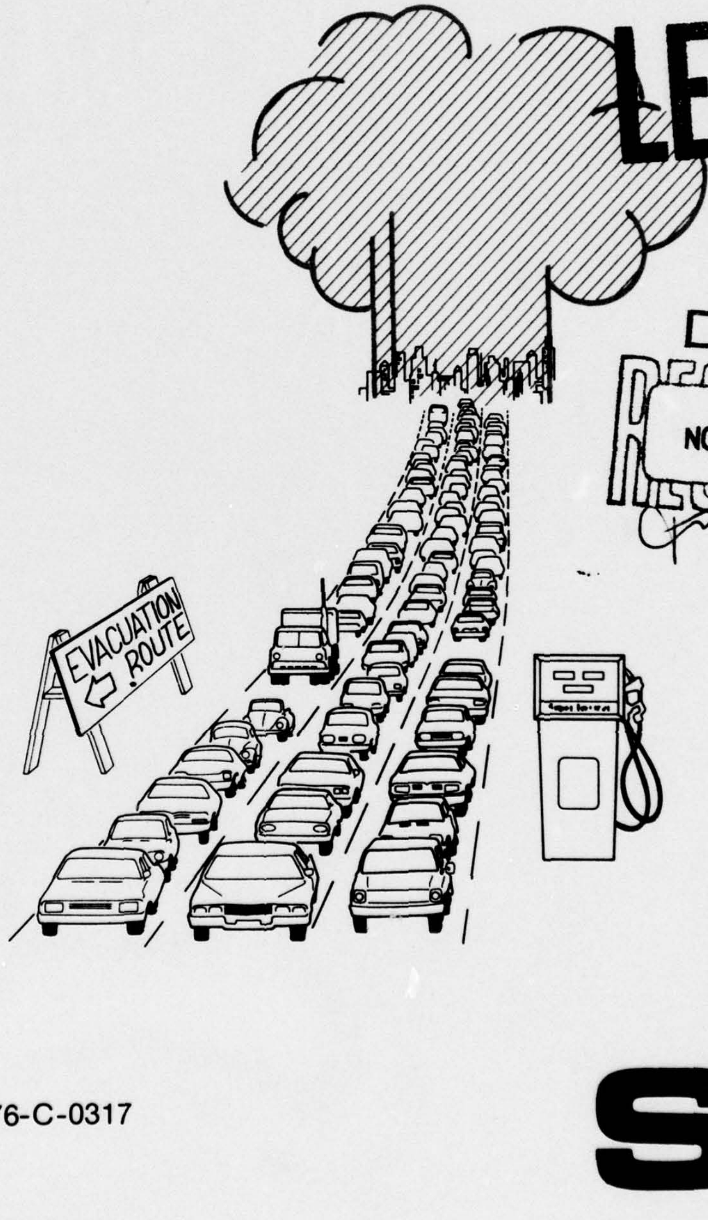


FINAL REPORT — VOLUME II

Postattack Impacts of the Crisis Relocation Strategy on Transportation Systems

REVISED PLANNING GUIDELINES



Contract DCPA 01-76-C-0317
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POSTATTACK IMPACTS OF THE CRISIS RELOCATION STRATEGY ON TRANSPORTATION SYSTEMS

Volume II. Revised Planning Guidelines.

14 SYSTAN-D151-2

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For:

Defense Civil Preparedness Agency
Washington, D.C. 20301
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PREFACE

This report was prepared as part of a series of concurrent studies undertaken by the Defense Civil Preparedness Agency to investigate the potential planning and implementation problems associated with a crisis relocation strategy designed to transfer populations from high-risk areas during periods of severe international crisis. The report was prepared under Contract DCPA01-76-C-0317, and addresses the problems incurred in providing transportation support to survivors of a nuclear attack preceded by a crisis relocation. The research described in the report was accomplished over a one and one-half year period in the Los Altos, California offices of SYSTAN, Inc. under the direction of Dr. John W. Billheimer, with assistance from Mr. Arthur Simpson and Ms. Gail Fondahl. Mr. Simpson was responsible for assembling information on the existing road, rail and fuel distribution networks, and assessing nuclear attack damage at national and local levels. Ms. Fondahl helped to assemble and interpret data on road networks, and developed simplified procedures for computing transportation stress. Mr. Ed Slibeck of the National Transportation Fueling Corporation provided invaluable information on truckstops, while Ms. Carole Parker organized and edited the final report.

In serving as technical monitor on the project, Mr. Steve Birmingham of DCPA provided technical guidance throughout the investigation, and helped to establish convenient avenues of liaison with concurrent crisis relocation studies. At the national level, Mr. George Van den Berghe and Mr. Hanford Edsall of DCPA also supplied useful guidance, while Mr. Frank Mollner of DCPA Region VI provided valuable background information on the Colorado Springs Study Area.

This research on "Postattack Impacts of the Crisis Relocation Strategy on Transportation Systems" is reported in four volumes:

Volume I: Analysis and Case Study

Volume II: Revised Planning Guidelines

Volume III: The Role of Truckstops in Crisis Relocation

Volume IV: Prototype Plans for State of Colorado, El Paso County and Fremont County (limited distribution)

SUMMARY

INTRODUCTION

Research undertaken in the mid-1960's assessed the effects of nuclear attack on components of the national transportation network under a strategy of in-place protection. More recent investigations have studied alternative strategies for transporting people and critical commodities from areas of high risk in anticipation of a nuclear attack. The current study extends the previous research by (1) investigating the effects of a nuclear attack on the reconfigured transportation system and the relocated population following an evacuation of high-risk areas, (2) identifying and evaluating alternative means of providing transportation system support to the relocated survivors of such an attack, and (3) reviewing existing relocation guidance in the light of probable postattack consequences. This research evaluates the problem of providing transportation system support following both a relocation effort and a nuclear attack, and systematically proposes and evaluates alternative solutions to this problem. Where applicable, the proposed solutions are examined in detail in a case study of Colorado Springs, Colorado.

PAST RESEARCH

Impacts of Crisis Relocation on Transportation Systems

Past studies have identified no potential transportation problems severe enough to render a crisis relocation strategy unworkable. The nationwide availability of vehicles far exceeds the anticipated demand, so that the chief limitations to the effective use of these vehicles are likely to be administrative problems of organization and deployment. The capability of local road networks will be stretched, particularly on the first day of relocation, but careful planning and scheduling coupled with the continuous monitoring and broadcasting of traffic conditions should enable these networks to handle the load in most U.S. cities.

Since the demand for motor fuel during and after relocation is not likely to exceed normal demand, the chief fuel problem will be one of redirecting the flow of gasoline from risk areas to host areas, so that supplies are available where they are needed and reserves may be built up in relatively invulnerable locations.

Past Postattack Research

Earlier studies of transportation system vulnerability under a strategy of in-place protection have indicated that the surviving aggregate inventories of critical transportation equipment, roadways, classification centers, and personnel will be more than adequate for the delivery of food and other essential goods and services. These studies indicate that damage to the U.S. fuel supply system would be relatively heavy, and that regional fuel imbalances could be a serious postattack problem.

Implications of Previous Research

While certain potential postattack problems may be alleviated by a relocation strategy, other problems will be intensified. The extensive vehicle movement and fuel stockpiling accompanying the relocation strategy will render both of these elements less vulnerable to nuclear attack. However, the survival of additional people in areas removed from traditional distribution centers can be expected to intensify the stress imposed on the damaged transportation system. Although the relocation itself will have no impact on the vulnerability of such fixed elements as the road network or fuel refineries, demands on these elements in the postattack period will be greatly affected by the relocation strategy. Damaged roadways will increase the transportation distances covered in providing critical supplies, and this additional distance, coupled with the survival of additional population, will create increased demands on surviving fuel refineries.

DAMAGE ASSESSMENT ANALYSIS

Under a crisis relocation strategy, approximately 98 percent of the Colorado Springs risk and host area population is expected to survive a nuclear attack. The comparable nationwide figure is 90 percent survival. These survivors will impose demands on three principal components of the national and local transportation system: vehicles, road and rail networks, and fuel.

Vehicle Survival

Vehicle availability is not expected to be a limiting factor on the movement of goods and people following an attack. In Colorado Springs, more than twice as many trucks, buses and locomotives will survive an attack following a crisis relocation strategy as are likely to survive under a strategy of in-place protection. To the extent possible, such critical vehicles as debris-removal equipment, switching locomotives, and dump trucks should be moved to the host area as part of the relocation effort, along with a supply of spare parts and maintenance manuals for all vehicles.

The most critical problem with transportation equipment under a crisis relocation strategy is likely to be one of organization and coordination. This is expected to be especially true following an attack. Although the surviving vehicle supply is expected to be more than adequate for carrying essential supplies, clear lines of authority and advance planning will be needed to ensure that the vehicles are in the right place at the right time with the right orders.

Road and Rail Network Survival.

Road Network. Key highway links were cut in every major city targeted in the postulated attack. Although past studies have determined that detour routings could be found around every damaged link, the current investigation estimated that such detours would increase travel times by factors ranging from 22 to 38 percent. Precise nationwide estimates of postattack travel distances and demands would require a model of nationwide commodity movement over the existing road network. Such a model was beyond the scope of the current study, but should be incorporated in future reserach efforts as a basis for assessing postattack travel distances, vehicle requirements, and fuel consumption.

Truckstops. In the two decades since they became a prominent part of the intercity transportation picture, the more than 3,000 truckstops located along the nation's highway system have proven themselves to be an invaluable source of emergency assistance to travelers and commercial truckers in natural disasters. Nearly 70 percent of these truckstops would survive a nuclear attack. The relative invulnerability of truckstops to nuclear attack, coupled with their importance in the day-to-day movement of intercity cargo make them a valuable resource in any crisis relocation plan. A companion report discusses the role of truckstops as traffic control centers under crisis relocation conditions. In addition to their traditional roles as fueling points, these control centers would also act as: (1) checkpoints for rerouting or reassignment of essential shipments; (2) interim consignment points for non-essential shipments; (3) relay points for drivers; (4) coordination and reassignment points for cabs and drivers; and (5) central assignment points for mechanics. To make maximum use of truckstops as an emergency resource, an attempt should be made to form a voluntary organization of truckstop owners capable of providing an emergency fueling capability for vehicles and havens of rescue for drivers and passengers in times of crisis.

Rail Network. If a nuclear attack were to occur, the nation's rail network would suffer heavy damage, with 41 percent of the classification yards and 53 percent of the repair shops surviving. It appears that the rail system could be 30 to 50 percent operational, but with reduced efficiency, within 30 days after the postulated attack. In general, damage and debris will cause considerable curtailment of rail service in the immediate postattack period, and a greater share of the nation's cargo will initially be carried by the more flexible trucking system.

In planning for postattack rail movement, key host-area terminals which could be used as control centers in time of crisis should be identified in the preattack period, and plans for the expansion and use of these terminals should be incorporated in appropriate crisis relocation planning documents. This has been accomplished for the Colorado Springs risk area. During the crisis relocation period, emergency power-generating equipment should be moved to these terminals, and rail panels for repairing track damage should be loaded on flatcars and spotted on sidings at various locations in the host area.

Fuel System Survival

An analysis of the damage to U.S. and Colorado petroleum production and distribution facilities indicates that severe fuel shortages would probably follow a nuclear attack. The destruction of national and local refineries, storage facilities, and pipelines would necessitate changing patterns of distribution and strict fuel use controls.

The two largest refineries located in Colorado and all Denver pipeline terminals would be severely damaged by the postulated attack, and would not be operational in the first postattack year. Nonetheless, up to 60 percent of colorado's preattack fuel supply could be transported by truck from undamaged supply points in Wyoming and Texas. At the national level, however, only 30 percent of U.S. refinery and storage capacity is expected to survive the postulated attack; therefore, it is anticipated that federal reallocations will effectively cut Colorado's fuel supply to 30 percent of preattack levels.

Following a crisis relocation prior to an attack, fuel requirements are expected to drop to between 35 and 40 percent of normal daily usage. As the nation's production capacity will far exceed consumption rates during this period, excess supplies should be stockpiled in host area storage tanks to alleviate anticipated postattack shortages. Rigid control and conservation measures such as rationing, vehicle impoundment, and restriction of unnecessary cargo shipments will be necessary following an attack. Introduction of these measures during the relocation period will allow these procedures to be tested under somewhat less harrowing ircumstances and increase the supply of fuel available for stockpiling. Critical petroleum production and distribution facilities on the fringes of anticipated target areas should be protected with sandbags, steel mesh, and earth embankments during the relocation period.

The available fuel supply will be the constraining element in the postattack management of the transportation system. In this regard, fuel shortages will be more critical than either vehicle losses or road damage. However, there should be sufficient fuel to support the movement of food and other essential commodities if its use is carefully controlled.

ANALYSIS OF AN EXTENDED CRISIS SITUATION

If the initial crisis relocation is not followed by an attack or a cessation of hostilities, an extended relocation may result in which risk area residents remain for relatively long periods of time within the host area. In the event such an extended relocation period occurs, several adjustments might be made in the relocation posture. For example, the number of critical industries and commuting workers might be increased, while some non-critical activities may be transplanted from the risk to the host area and restarted for the duration of the extended relocation period. At the same time, stockpiles of critical commodities could be amassed in the host area. Such adjustments could have poten-

tially large impacts on the transportation network and fuel supply system. As part of the current investigation, a range of adjustments associated with an extended relocation period was postulated, the transportation impacts of these adjustments were quantified, and alternatives for providing transportation support throughout the extended period were proposed and evaluated.

Analysis of the extended crisis situation in Colorado Springs indicated that none of the anticipated adjustments generated excessive transportation or fuel support requirements. An extended crisis period would provide additional time to stockpile fuel supplies in the host area, and it is strongly recommended that such a stockpiling strategy be followed. In Colorado Springs, secondary bulk storage facilities and gasoline station storage tanks would be filled to capacity in a little more than one week following the completion of relocation. It is likely, then, that a strategy of fuel stockpiling under extended crisis conditions will require the creation of additional fuel storage capability in host areas. Construction of traditional bulk storage facilities would require several months. Possible alternatives for providing such additional storage in a shorter time period include:

- Filling the tanks of impounded automobiles;

- Building expedient storage facilities using collapseable rubber-plastic containers in earthern embankments; and

- Using underground storage.

In addition to fuel, food supplies such as dried milk, canned meat products, and raw grain likely to be in short supply or geographically inaccessible following an attack should be stockpiled in host areas under extended crisis conditions.

IMPLICATIONS OF POSTATTACK RESEARCH ON CRISIS RELOCATION GUIDANCE

The results of the postattack research on the Colorado Springs study area have been reviewed in light of the current guidance for crisis relocation planning. As a result of this review, it appears that the basic strategy proposed for providing transportation under crisis relocation conditions is sound, although certain changes and additions are recommended. The analysis accompanying the damage assessment and evaluation procedures brought to light several elements which should be included in the crisis relocation guidance issued by the federal government and in the crisis relocation plans for specific areas. These elements include:

1. Provision for moving critical vehicles (such as switch engines and debris-removal equipment) out of risk areas where possible, and assembling parts inventories within the host areas;

2. Guidelines for identifying key host area railyards and planning for their expansion;

3. Guidelines for preparing a list of critical pipeline repair facilities and plans to protect them;

4. Provision for stockpiling fuel as soon as possible during crisis relocation, for constructing expedient bulk storage facilities within the host area, and for supporting plans for peacetime crude stockpiles and research into expedient storage structures and product storage; and

5. Provision for identifying key host- and risk-area truckstops, outlining the role of these truckstops under crisis relocation conditions, and forming a peacetime organization of truckstop owners.

These elements, along with general postattack guidance for transportation system management, have been incorporated in prototype crisis relocation plans for the State of Colorado, the risk area of El Paso County, and a sample host area, Fremont County. Guidelines for state and local relocation planners have been updated to reflect these elements, as well as other concerns identified in extensive interviews with planners and industry personnel. A summary of the revised guidelines appears in the accompanying exhibit.

EXHIBIT S.1

RECOMMENDED GUIDELINES FOR TRANSPORTATION SUPPORT OF THE CRISIS RELOCATION STRATEGY

STATE AND REGIONAL ACTIVITIES

- Revise fuel distribution patterns from secondary sources to the consumer
- Arrange for additional drivers and equipment needed to distribute food, fuel, & other critical items.
- Waive vehicle highway weight restrictions
- Publicize revised regulations and chain of command.

	GENERAL GUIDELINES	RISK AREA ACTIVITIES	HOST AREA ACTIVITIES
POPULATION MOVEMENT	• Most evacuees will relocate in private automobiles. • Autoless residents should proceed to nearest school or polling place in accordance with publicized schedules.	• Evacuees with autos should maximize vehicle occupancy & schedule departures to minimize likelihood of congestion. • Local buses should operate on reduced holiday schedules during early stages of relocation. Remainder of fleet will be used in evacuation. In most cities, school buses, public transit, & local tour buses will be adequate to relocate autoless residents; intercity buses should be directed to cities with vehicle shortages. Bus departures should be scheduled to minimize congestion. • Rail passenger service should be used where possible. Heavy trucks and boxcars can supplement evacuation vehicle fleet in cases of extreme emergency.	• Use of private autos will be restricted once host area is reached. • Following relocation, risk area buses will provide public transportation capability in host area. • Buses & carpools should be used to extent possible in commuting of critical workers.
CARGO MOVEMENT	• Intercity cargo flow will generally follow normal patterns, with movements restricted to critical goods. • Local cargo flow will be restricted to movement of critical goods, but travel distances will be increased, increasing requirements for vehicles & drivers carrying critical commodities. • Specialized motor vehicles (e.g., ambulances, dump trucks, debris-removal equipment) and critical rail rolling stock will be evacuated to host areas; spare parts will be stockpiled in safe locations.	• Continue to operate all major fuel wholesale operations, primary & secondary fuel storage terminals, & other distribution facilities for critical commodities. • Augment vehicle fleet & driver pool for transportation of critical goods as required, following guidelines & procedures established by NDTA for obtaining personnel & equipment from less critical sectors. • Increase vehicle & driver productivity by taking advantage of waived restrictions & weight limitations; minimizing down time; relaxing maintenance requirements; increasing vehicle loads; loading only full pallet quantities; & shipping only necessary commodities. Relocate specialized motor vehicles, critical rolling stock and repair equipment to host areas.	Continue all warehousing & distribution activities for critical goods, expanding operations where possible through use of commandeered space, worker overtime, & relocated workers. Augment transportation fleet & driver pool as required, following guidelines and procedures established by NDTA for obtaining personnel & new equipment from other sectors. Increase vehicle & driver productivity by taking advantage of waived driver restrictions & weight limitations; minimizing down time; relaxing maintenance requirements; increasing vehicle loads; loading only full pallet quantities; & shipping only necessary commodities. Stockpile vehicle parts and maintenance manuals.
ROAD NETWORK UTILIZATION	• Advance planning should identify bottlenecks & use all available roads to maximize outbound flow. Effects of congestion on road capacity should be explicitly considered, & contingency plans should be developed to bypass congested bottlenecks. • Traffic flow should be monitored throughout relocation period, preferably by helicopter. • Police & emergency rescue vehicles should patrol evacuation routes to remove disabled vehicles.	• All available means should be employed to persuade population to limit number of vehicles used in evacuation & spread departures evenly over three-day relocation period. • Frequent reports on traffic conditions should be provided throughout the relocation period to allow departing evacuees to enter traffic flow streams at optimal times & to permit motorists to adjust travel plans en route. • Where the possibility of congestion is high, license plate controls should be used to schedule departures. • Move rail panels to host area on flatcars.	• Reception stations should remain open around the clock to facilitate spreading of risk area departure times. • Service stations & rest areas will serve as staging points for emergency vehicle patrols during relocation. • Identify key host area terminals (truckstops and railyards) in advance and plan for their support.
FUEL CONTROL AND DISTRIBUTION	• If fuel shortages do not exist prior to relocation, they are not likely to occur during or after relocation. However, rationing & other point-of-purchase controls may be desirable to conserve fuel against the shortages that can be expected if an attack ensues. • The flow of motor fuel will be redirected from risk area terminals & stations to host area bulk terminals & gas stations. • Intercompany fuel transfers should be permitted to facilitate the redirection of flow from risk to host areas. • To the extent possible, vehicles moving between risk & host areas with critical workers & commodities should refuel in the risk area. • Restrictions on the use of leaded fuel should be eliminated. • Excess fuel produced during relocation period should be stockpiled in host areas.	• Secondary bulk terminals and pipeline outlets will continue to operate to supply host area stations & terminals & critical risk area stations. Once the relocation order is given, only a limited number of critical stations will be resupplied. Where possible, risk area pipeline outlets should supply these stations. • All gasoline stations should remain open around the clock during three-day relocation period until their tanks are drained. Following relocation, only critical stations will remain open. • Non-critical stations with fuel remaining following relocation should deposit keys with public safety officials so that inventories can be used to support movement of critical workers & commodities. • Stations should observe rationing controls & odd/even regulations established nationally during pre-crisis period & evacuation period. • Strengthen critical pipeline terminals and refineries on fringes of target area against attack.	• Supplies to stations along evacuation routes will be bolstered. These stations should remain open around the clock during relocation. • Where appropriate, host area pipeline terminals should be used to advantage in diverting flow of motor fuel. • Following relocation, deliveries to bulk terminals & gasoline stations will be stepped up to meet relocated demand & to develop fuel stockpiles in less vulnerable locales. • Stations should observe rationing controls, odd/even regulations, & any purchase restrictions established nationally before & after relocation. • Construct expedient fuel storage facilities where necessary.

VOLUME II

REVISED PLANNING GUIDELINES

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CHANGES IN GUIDELINES

A previous investigation of the impacts of the crisis relocation strategy on transportation systems[1] led to the preparation of guidelines for planners and officials charged with the responsibility of developing relocation plans at the regional, state, and local levels. The results of the postattack research described in Volume I of this report, coupled with subsequent discussions with planners, DOT officials, and transportation industry personnel, have suggested the need for revising and updating the original guidelines to reflect a number of factors, including:

- Postattack guidance for transportation system management;
- Provisions for moving critical vehicles (such as switch engines and debris-removal equipment) out of risk areas where possible, and assembling parts inventories within the host area;
- Guidelines for identifying and protecting critical pipeline terminals and pipeline repair facilities;
- Provision for stockpiling food in host area bulk storage facilities and retail outlets;
- Guidelines for including truckstops in emergency plans and forming an emergency organization of truckstop owners; and
- Additional guidance for the disposition of essential and non-essential intercity shipments in transit at the time the relocation order is given.

In this volume, the three major sections of the past guidelines dealing with Vehicles (Section A), Roads (Section B), and Fuel (Section C) have been updated to reflect the above factors, as well as other concerns affecting both pre-attack planning guidance and postattack operations. The general scope of the revisions is outlined below by section:

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[1] Billheimer et al., "Impacts of the Crisis Relocation Strategy on Transportation Networks," SYSTAN Report No. D147 prepared for the Defense Civil Preparedness Agency under Contract DCPA01-75-C-0263, Washington, D.C., August 1976.

A. Vehicles. Provision for moving critical vehicles and parts to the host areas during crisis relocation were added to existing guidelines, as were basic rules for the disposition of intercity cargo.

B. Roads. Additions to this section focus on emergency planning in the rail industry; strategies for moving rail panels and critical rolling stock to the host area are considered, and plans for identifying and expanding key host area railroad terminals are discussed.

C. Fuel. Methods of expanding fuel output, stockpiling fuel in the host area during the crisis relocation period, and protecting critical pipeline terminals are examined in the additions to this section.

The following new data were provided on vehicles, roads, and fuel for postattack conditions:

A. Vehicles. A brief discussion of the probable postattack situation has been added, the need to rely heavily on trucks rather than rail in the immediate postattack period is noted, and strategies for relieving transportation stress by improving vehicle utilization are discussed.

B. Roads. Nationwide damage to the road and rail network is summarized, the need for alternative detour routes is discussed, and the increased truck travel imposed by detours is broadly estimated.

C. Fuel. The probable postattack fuel situation is summarized, and transportation-related measures to avert postattack fuel shortages is

discussed. These include assigning top priority to the repair of refineries and pipelines, using tank trucks to bypass damaged links in the pipeline network, and introducing rigid control and conservation measures.

Planning Guidelines for Transportation Support of the Crisis Relocation Strategy

I. INTRODUCTION

This volume of the report is directed toward state and local officials charged with the task of developing crisis relocation plans for their jurisdictions. Guidelines are presented which will enable these officials to obtain the necessary data for planning and to formulate plans for the transport of people and critical cargo under crisis relocation conditions. These guidelines rely heavily upon existing data sources, contacts with transportation planners, freight haulers, Federal, state and local transportation agencies, and petroleum industry leaders, and a compendium of rules of thumb and distilled conventional wisdom assembled in past studies. It is intended that the guidelines should prove useful not only in crisis relocation planning, but also in monitoring the hazard state of the system during evacuation and in projecting future hazard states.

A. Background

A.1 Two Planning Approaches

There are at least two diverse strategies which may be used in approaching the planning considerations posed above and identifying transportation requirements of a community. These two strategies may be characterized as the "top down" and "bottom up" approaches. Planners using the "top down" approach rely heavily on published statistics (Census data, USDA statistics, trade profiles, etc.) to provide a picture of transport systems and patterns. Those using the "bottom up" approach attempt to identify patterns

of transportation by undertaking extensive interviews with those industry personnel and public officials actually responsible for that movement in a community. These two approaches are not mutually exclusive, and both should be applied to obtain a comprehensive picture of a community's transportation. One of the most important features of a community's crisis relocation plan is the identification of those local industry leaders and public officials who are familiar with the transportation system and requirements and who have a good understanding of the ways in which the operations may be modified to meet crisis relocation requirements. The identification and briefing of these industry leaders and public officials will be at least as important to the successful implementation of a crisis relocation plan as the identification of transport system facilities and operations.

B. Organization

Planning guidelines presented in Section II of this report are organized under the following headings:

A. Vehicles

B. Roads

C. Fuel

Within these headings, four general topics are addressed in Section II:

- Published data sources for the "top down" approach;
- Information sources and data for the "bottom up" approach;
- Planning guidelines including
  - (i) Rules of Thumb and Distilled Conventional Wisdom
  - (ii) Promising Analytical Approaches
  - (iii) Summaries of Required Information.

Detailed tabular data supporting the planning guidelines and providing additional planning information have been included in three appendices corresponding to Categories A through C.

II. PLANNING GUIDELINES AND APPROACHES

This section discusses crisis relocation planning guidelines and approaches for each element of the transportation system. Primary attention is focused on those elements of the transportation system within the control of state and local planners under crisis relocation conditions.

A. Vehicles

A.1 Overview of National and Local Systems - Vehicle Inventories and Usage Patterns

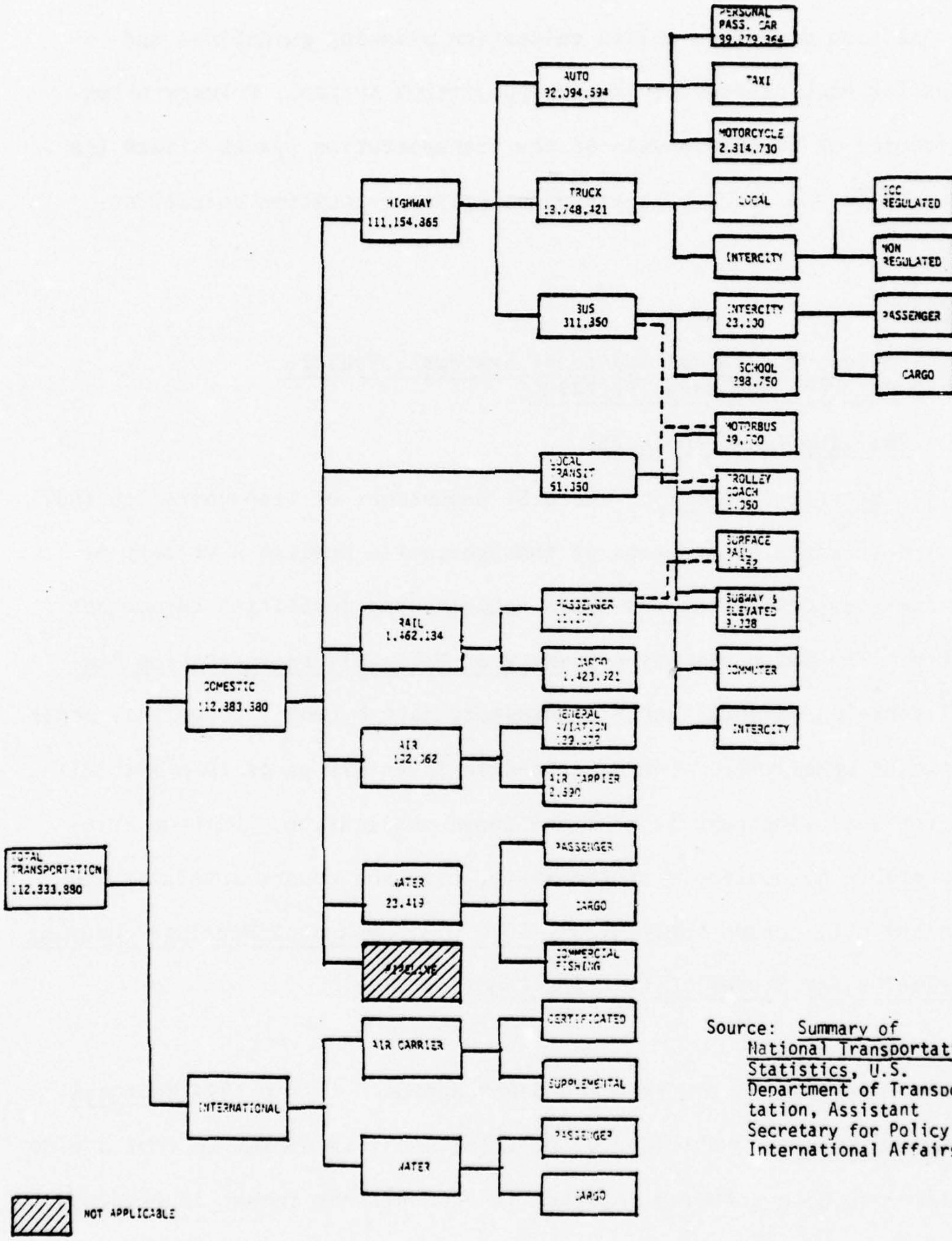
A.1.1 The "Top Down" Approach

A.1.1.1 Vehicle Inventory. The U.S. Department of Transportation (DOT) and the various state departments of transportation publish a variety of timely statistics describing transport vehicles and facilities throughout the country. The DOT publication Summary of National Transportation Statistics[A1] contains national vehicle inventory data by mode, as well as other transportation statistics. The U.S. vehicle inventory as of 1970 (Exhibit II-1) on the following page is from the above publication. Data on automobile ownership by household at the state, city and county levels is contained in the U.S. Census publication, 1970 U.S. Census of Housing: Housing Characteristics for States, Cities and Counties.[A2]

A useful publication for the "top down" approach is the 1974 National Transportation Report,[A3] published by DOT. The study is useful in that a wide body of data has been gathered together in a consistent format in one report. The study has sections on highways, urban mass transportation, airport systems, marine terminals, and intercity bus, railway, and trucking terminals.

EXHIBIT II-1

NUMBER OF VEHICLES, 1970



Source: Summary of National Transportation Statistics, U.S. Department of Transportation, Assistant Secretary for Policy & International Affairs.

All modes are included, public as well as private. Data on vehicle inventories and usage patterns are also included. These data are available for each city in the United States with more than 50,000 residents in 1970, and hence for most of the cities judged to be at risk in time of crisis. Appendix Exhibit A.1-1 shows sample urban public transportation data from the National Transportation Study; it can be seen that the exhibit provides data on the city, bus route mileage, number and age of vehicles, average number of seats, and other data useful for crisis relocation planning. Appendix Table A.1-2, a summary of public transit vehicle availability, is also based on the National Transportation Study.

The annual report Motor Truck Facts,[A4] published by the Motor Vehicle Manufacturers Association, is a source of truck and trailer inventory information. The Bureau of the Census publication 1972 Census of Transportation Truck Inventory and Use Survey[A5] provides detailed truck and trailer inventory data for each state, including size, weight, body type, number of axles, and type of fuel.

A.1.1.2 Vehicle Usage. Motor vehicle usage on the national level is broadly summarized in Highway Statistics, 1974,[A6] published by DOT. Data is provided on total vehicle miles traveled by all vehicles, and a breakdown by personal vehicles, buses and cargo vehicles. Data is also provided on travel by type of road and total fuel consumption (Table II-1).

More detail on personal vehicle usage patterns is contained in Nationwide Personal Transportation Study[A7] published by DOT. Some of this data has been summarized and presented in graphic form by the Motor Vehicle Manufacturers

TABLE II-1

ESTIMATED MOTOR VEHICLE TRAVEL IN THE UNITED STATES AND RELATED DATA—1973[1]

Source: Program Management Division
Office of Highway Planning, FHWA

NOVEMBER 1974

ITEM	PASSENGER VEHICLES							CARGO VEHICLES			ALL MOTOR VEHICLES
	PERSONAL PASSENGER VEHICLES			BUSES			ALL PASSENGER VEHICLES	SINGLE-UNIT TRUCKS	COMBI-NATIONS	ALL TRUCKS	
	PASSENGER CARS 2/	MOTOR-CYCLES 2/	ALL PERSONAL PASSENGER VEHICLES	COMMERCIAL	SCHOOL	ALL BUSES					
Motor-vehicle travel:											
(million vehicle-miles)											
Main rural roads			341,633	890	920	1,810	343,443	86,764	32,772	119,536	462,979
Local rural roads			102,631	113	995	1,108	103,739	33,292	1,165	34,457	138,196
All rural roads			444,264	1,003	1,915	2,918	447,182	120,056	33,937	153,993	601,175
Urban streets			592,191	1,545	497	2,042	594,233	99,072	14,082	113,154	707,387
Total travel	1,016,861	19,594	1,036,455	2,548	2,412	4,960	1,041,415	219,128	48,019	267,147	1,308,562
Number of vehicles registered (thousands)	101,762.5	4,356.5	106,119.0	89.5	336.0	425.5	106,544.5	22,205.0	1,027.9	23,232.9	129,777.4
Average miles traveled per vehicle	9,992	4,498	9,767	28,469	7,178	11,662	9,774	9,868	46,716	11,538	10,083
Fuel consumed (million gallons)	77,619	392	78,011	520	327	847	78,858	22,755	8,860	31,615	110,473
Average fuel consumption per vehicle (gallons)	763	90	736	5,810	973	1,991	741	1,025	8,620	1,361	851
Average miles traveled per gallon of fuel consumed	13.10	50.00	13.29	4.90	7.37	5.86	13.21	9.63	5.42	8.45	11.85

1/ For the 50 States and District of Columbia.
2/ Separate estimates of passenger car and motorcycle travel are not available by highway category.

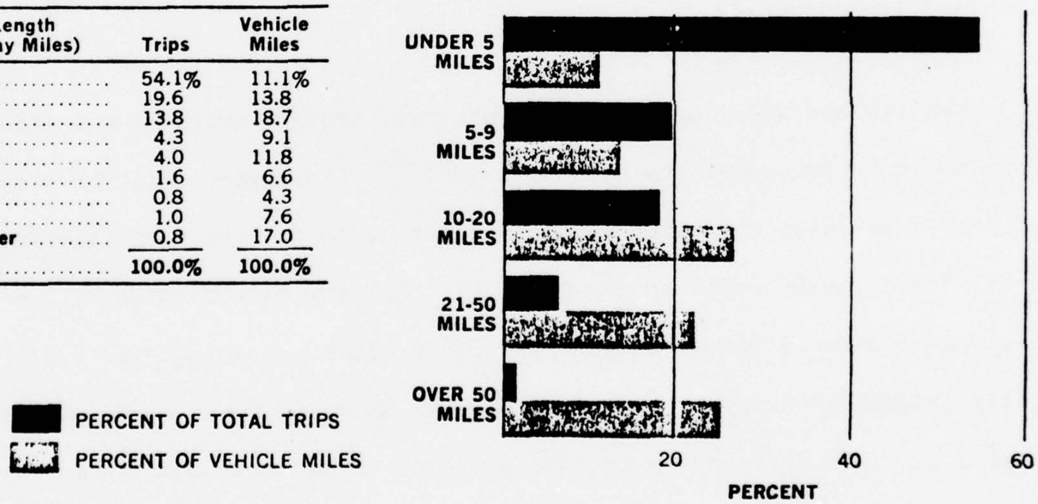
EXHIBIT II-2

PASSENGER CAR USE

Purpose of Travel	Percentage Distribution Trips	Percentage Distribution Travel	Average Trip Length One-Way (Miles)	Average Occupants Per Car
Earning a living:				
To and from work	32.3%	34.1%	9.4	1.4
Business related to work	4.4	8.0	16.1	1.6
Total	36.7	42.1	10.2	1.4
Family business:				
Medical and dental	1.7	1.6	8.4	2.1
Shopping	15.4	7.6	4.4	2.0
Other	14.1	10.3	6.5	1.9
Total	31.3	19.6	5.6	2.0
Educational, civic or religious	9.4	5.0	4.7	2.5
Social and recreational:				
Vacations	0.1	2.6	160.0	3.4
Visit friends or relatives	9.1	12.2	12.0	2.2
Pleasure rides	1.4	3.1	20.0	2.7
Other	12.0	15.4	11.4	2.6
Total	22.6	33.4	13.1	2.5
All purposes	100.0%	100.0%	8.9	1.9

LENGTH OF TRIPS

Trip Length (One-Way Miles)	Trips	Vehicle Miles
Under 5	54.1%	11.1%
5-9	19.6	13.8
10-15	13.8	18.7
16-20	4.3	9.1
21-30	4.0	11.8
31-40	1.6	6.6
41-50	0.8	4.3
51-99	1.0	7.6
100 and over	0.8	17.0
Total	100.0%	100.0%



SOURCE: U.S. Department of Transportation, Federal Highway Administration, *Nationwide Personal Transportation Study* (1969), Reports No. 1 and 7.

Association of the United States, Inc., in 1973/74 Automobile Facts and Figures[A8] (see Exhibit II-2).

Another publication containing much useful data on vehicle usage is Urban Transportation Factbook[A9] published by the American Institute of Planners and Motor Vehicle Manufacturers Association of the United States. For example, this publication contains data on tripmaking distribution location, purpose and mode, and average work-trip length for the 33 largest Standard Metropolitan Statistical Areas (SMSA's) in the United States. Included is a comparison of population density and households without automobiles (Appendix Exhibit A.1-3), and of public transit usage, population density, and automobile ownership for the 33 largest SMSA's. In addition, data is presented on the usage of urban transport facilities by mode, and automobile availability by multi-auto households.

A complete and detailed survey of intercity freight movement was carried out by the U.S. Bureau of the Census in 1967.[A10] The survey includes nationwide and state-level ton and ton-mile statistics on intercity freight movements. The state-by-state survey provides commodity data by mode with a breakdown of commodities by shipper group and class. A summary of U.S. intercity freight movement by transport mode is shown in Table II-2. The survey also provides data on the average distance of shipment and percent distribution weight by mode for shipper group and class. Similar data is also summarized for the United States as a whole. The United States summary data shows the percent distribution of tons of shipments by type for geographic divisions of origin and destination.

TABLE II-2

U.S. INTERCITY FREIGHT MOVEMENT BY MODE, 1967,

ALL SHIPPER GROUPS

(In tons and ton miles)

TRANSPORT MODE	VOLUME TRANSPORTED (thousands of tons)	SHARE OF TOTAL (%)	MILLIONS OF TON MILES	SHARE OF TOTAL (%)
Motor Carrier	369,402	26.7 %	99,812	14.7 %
Private Truck	190,892	13.8	29,197	4.3
Total Truck (Sub-Total)	560,294	40.5	129,009	19.0
Rail	454,460	32.8	249,869	36.8
Other	369,863	26.7	300,114	44.2
All Transport Modes	1,384,617	100.0 %	678,992	100.0 %

(Source: Reference A-10)

The DOT publication Summary of National Transportation Statistics contains useful data on U.S. freight movement. The annual issues of Motor Truck Facts,[A4] published by the Motor Vehicle Manufacturers Association, also has useful statistics on and graphic presentations of freight movement and truck use.

Other sources of vehicle information are the National Association of Motor Bus Operators, American Trucking Association, American Association of Railroads, and the Interstate Commerce Commission.

A.1.2 Bottom Up Approach

A.1.2.1 Vehicle Inventories. At the county or city level, useful data on vehicle inventories and current use may be obtained from interviews with common carriers: bus, truck, taxi companies, and railroads. Information on public transport buses and taxis is available on a city-by-city basis in the 1974 National Transportation Study. Private carriers may also be helpful sources of information, particularly the larger ones (e.g., oil companies, wholesale or retail chains operating their own truck fleets).

Another valuable source of information is the National Defense Transportation Association (NDTA). Local representives of NDTA should be able to furnish valuable data on vehicle inventories and other transportation information. The NDTA is a non-profit organization dedicated to transportation preparedness, and is composed of volunteers drawn from privately-owned transportation firms. The association presently has 100 chapters in the United States and overseas, and a membership of over 12,000. Its head-

quarters are located in Washington, D.C. Among the organization's stated objectives is the provision of active assistance to appropriate government agencies engaged in transportation preparedness planning. Assistance is offered in:

- ° Overall operational planning for emergencies, such as one-site assistance programs;
- ° Voluntary training;
- ° Provision of inventory data on transportation resources, surveys and damage assessment;
- ° Transportation of essential supplies and equipment from warehouses or other locations to relief centers and/or fallout shelters; and
- ° Transportation of civil defense personnel and emergency assistance workers.

State highway department personnel, county and city planning departments, city traffic departments, local Chambers of Commerce, motor carriers associations, county registrar's offices, and regional DCPA personnel may also be helpful in providing data on vehicle inventories or assisting in the location of reports already published.

A.1.2.1 Vehicle Usage. Automobile usage data for local areas may often be obtained from already completed origin-destination surveys. In some cases, surveys have been carried out by cities, counties, or area government councils alone; in other cases, a study may have been conducted in cooperation with the State Department of Transportation and/or the U.S. Department of Transportation. Most of these studies were conducted in the middle-to-late-sixties, but the citywide data on trip purposes and distance traveled may still be valid. The appropriate local departments of transportation or planning will know of the existence of such surveys, and should be consulted regarding any adjustments in travel patterns occuring since the survey data.

Data on public transit service may be included in a local or regional survey of the type mentioned above. In addition, data on local public transit usage may be obtained from public transit authorities or the companies themselves. The state, city, or county departments of transportation or the NDTA may also provide data on public transit usage.

Surveys, if available, are also a good source of information on local truck movement. Another valuable source of information on local truck movement, of course, is the public and private carriers themselves, especially the larger common carriers and private companies with their own fleets (e.g., oil companies).

The following information should be sought in interviews with major common or private carriers:

Transportation Equipment Inventory

- Number of Tractors
- Number of Trailers and Capacities
- Miles per Gallon (loaded)
- Vehicle Range (miles per tank of gas)
- Vehicle Down Times by Season (hours per day)
- Average Loading Time (hours per truck)
- Total Hours of Use by Season (hours per day)

Driver Information

- Number of Drivers
- Regulatory Contraints on Driver Time
- Sources of Emergency Drivers

Cargo Information

- Total Volume per Year (ton-miles)
- General Types of Cargo Carried (% critical, % not critical)

In general, state, city or county departments of transportation (or planning departments), the NDTA, and public or private carriers may be good sources of information on vehicle usage and vehicle inventories.

A.2 Vehicle Requirements for the Movement of People Under CRP Conditions

The major transportation demands posed by a crisis relocation strategy include movement of evacuees out of the risk area; distribution of critical supplies such as food and fuel; commuting of critical workers; support of critical industries; and national defense. In this subsection, quantitative estimates are developed of the vehicle support needed for the movement of civilians during and after relocation. Traffic control measures and fueling needs are discussed in subsequent sections.

The chief demand for passenger transportation imposed by a crisis relocation strategy is created by the evacuation itself. If sufficient vehicles can be mobilized for the evacuation, vehicle shortages are not likely to occur in commuting critical workers and supporting necessary movements within and between host areas following relocation.

In most risk areas, the primary resource for relocation and return will be "first automobile" -- the best vehicle available to those families with one or more automobiles or other light vehicles. As indicated in Exhibit 2.3 of Volume I, about 80% of U.S. households own one or more cars. In the United States, there are more than 100 million automobiles to serve 214 million people; thus, in theory, everyone could leave a risk area by automobile. However, automobiles are not uniformly distributed among all segments of society and among all cities or risk areas. In New York City, about 60 percent of the households have automobiles, a relatively low share of the population. It has been determined, however, that risk areas with a population

of less than one million people exhibit some uniformity in availability of automobiles, with 85-95% of households having one or more. The number of persons in a risk area who may be assumed to leave by first auto may be illustrated as follows:

		Sample
1.	Population (from Census)	450,000
2.	Occupied dwelling units-ODU (from Census)	130,000
3.	Persons per ODU [(1)÷(2)]	3.46
4.	ODU's with autos (from Census)	90%
5.	Number (from Census)	117,000
6.	Persons evacuating by first auto [(3)X(5)]	405,000

Data on population and household automobile ownership by city and county is available in the <u>1970 U.S. Census of Housing: Housing Characteristics for States, Cities and Counties</u>.[A2]

From a planning standpoint, other means of transportation must be organized for the residents of those households without automobiles. Taking 15 percent as an upper limit on the number of autoless citizens to be evacuated in cities of under one million population, and 25 percent in cities of one million and over, Table II-3 indicates the mean number of round trips per bus necessary to evacuate cities of various sizes, assuming intraurban buses are used and that they are 75% full on the average.

Although the stratified estimates of autoless residents in Table II-3 are somewhat arbitrary, a consideration of the vehicle trips required to evacuate these residents indicates that the urban bus fleet alone is likely to be

TABLE II-3

ESTIMATES OF URBAN BUS TRIPS

NECESSARY TO RELOCATE AUTOLESS RESIDENTS

	URBANIZED AREA POPULATION CLASSIFICATIONS (THOUSANDS)						
	2,000 and over	1,000 & under 2,000	500 & under 1,000	250 & under 500	100 & under 250	50 & under 100	Total, all areas
POPULATION INFORMATION:							
No. of Areas	10	13	29	40	80	69	241
Total Population (thousands)	59,309	18,041	20,097	13,120	12,417	5,205	128,189
BUS INFORMATION:							
No. of Buses	26,680	6,992	5,768	3,186	2,666	909	46,201
Average Seats/ Bus	47.6	48.7	45.7	43.5	38.7	35.4	46.4
Estimated No. of Autoless Residents	14,827	4,510	3,014	1,968	1,862	781	26,962
No. of Urban bus Trips to evaluate autoless Residents	16	18	15	19	24	32	17

inadequate to the relocation task. The number of school buses, however, is nearly five times the number of urban buses. If these buses were brought into play, an all-bus evacuation of autoless residents would appear to be possible in many cities. On a nationwide basis, the seating capacity of school buses added to the seating capacity of urban buses would be sufficient to evacuate the 27 million autoless residents identified in Table II-3 in slightly over four trips, assuming buses were 75 percent full on the average (this allows for some baggage). In many cities, the local fleet of school buses and public buses could be augmented by intercity and tour buses with a greater capacity for carrying both baggage and passengers -- thereby reducing the number of trips required of each bus. To the extent possible, urban buses should attempt to provide scheduled service at reduced holiday frequencies during the first two days of the relocation period. This policy would free approximately half of the fleet for evacuation runs without depriving the transit-dependent of their accustomed means of transportation. On the third day of relocation, all buses should be dedicated to the evacuation process. To improve bus fleet utilization during relocation, those autoless residents relocated during the first day of evacuation should be taken to reception centers near the risk area.

Although the average risk area may expect to have sufficient buses available locally to transport its autoless residents, some localities will have to supplement the bus fleet with other vehicles; this is particularly true in the larger East Coast cities, where the proportion of autoless residents is the highest. The following subsection discusses the relative advantages and disadvantages of the various vehicles that might be employed in the evacuation process.

A.2.1 Advantages and Disadvantages of Alternative Evacuation Vehicles

Exhibit II-3 summarizes the relative advantages and disadvantages of the various surface vehicles that might be employed in the evacuation process. An approximate hierarchy of vehicle desirability appears below:

1. First automobiles;
2. Buses;
3. Rail passenger cars;
4. Second automobiles;
5. Heavy trucks; and
6. Rail freight cars.

The "first" automobile is the clear first choice for the evacuation process. These private vehicles will be supplemented in a variety of ways in different risk areas. In most cases, transportation for the autoless will be provided by a combined fleet of school buses, local urban buses, and tour buses. Intercity buses should continue along their scheduled routes, debarking passengers in host areas and picking up passengers in risk areas, until preselected risk areas in great need of additional buses are reached. These risk areas will generally be the larger cities serving as layover points for the intercity bus fleet.

In those few instances in which frequent rail passenger service exists and sufficient cars are available, this mode should be used to the fullest extent. Where buses and rail passenger transport are inadequate, the vast storage of "second" automobiles might be employed in the evacuation process,

EXHIBIT II-3

ADVANTAGES AND DISADVANTAGES OF ALTERNATIVE VEHICLES FOR PASSENGER EVACUATION

VEHICLE CATEGORY	CAPACITY (Persons)	PRINCIPAL ADVANTAGES	PRINCIPAL DISADVANTAGES	COMMENTS
AUTOMOBILES				
"First" Autos (Primary household vehicle)	6	Comfortable, private, convenient, widely available, provides door-to-door service,	Slight fuel inefficiency; potential for congestion where road capacity constraints exist.	Clearly the first choice for evacuation. All other resources should be considered secondary and used in the mix deemed appropriate by local planners.
"Second" Autos (Secondary household vehicles, company autos, new & used car inventories, rental autos)	6	Generally the same as above, except driver may need to be provided in some instances.	Availability of first auto to households intensifies the potential fuel inefficiencies & road congestion that would result from using second autos for evacuation.	Use should generally be discouraged to improve fuel efficiency and avoid stretching road capacity. Where road capacity is no problem, drivers are available and buses are in short supply, the second auto may be a source of transportation for the transit-dependent.
BUSES				
Large Intercity and Tour Buses	50	Maximum carrying capacity for people, baggage compartments for luggage; designed for comfortable, long-haul passenger service.	Widely dispersed at any given time; not generally under local control.	Use to fullest extent possible; best to plan on nationwide basis once local shortages have been identified. Buses should proceed along scheduled routes following relocation until points of maximum need are reached. These will generally be the larger cities serving as layover points for intercity buses.
Local Urban Buses	45	Good carrying capacity; generally under central local control.	No luggage facilities; need to maintain local service in early evacuation stages.	During the first two days of evacuation, some city buses should follow holiday schedule. Remainder of fleet should make round trips to nearby host areas. All buses should be devoted to evacuation on the third day of relocation.
School Buses	25	Widely available in relatively large numbers, generally under public control.	No luggage facilities; smaller, less comfortable, and generally lower maintenance standards than large buses.	Although not so desirable as larger buses, school buses will be needed in most cities to accomplish the relocation of the transit-dependent.

EXHIBIT II-3 Continued

ADVANTAGES AND DISADVANTAGES OF ALTERNATIVE VEHICLES FOR PASSENGER EVACUATION

VEHICLE CATEGORY	CAPACITY (Persons)	PRINCIPAL ADVANTAGES	PRINCIPAL DISADVANTAGES	COMMENTS
RAIL VEHICLES				
Passenger Cars in Commuter & Intercity Service	100 per car 1000 per train	Comfortable; high capacity, fuel efficiency; baggage-carrying capability; does not contribute to congestion.	Not generally available; regular service typically fails to serve host area; autoless will require feeder service.	Use where possible.
Rapid Rail Transit	50	Comfortable; high capacity; fuel efficiency; does not contribute to road congestion.	Not generally available; tracks rarely extend beyond risk area; feeder service needed.	Rarely feasible for evacuation service. Should remain in service during three-day relocation period to provide mobility for autoless.
Box Cars	65	Fuel efficiency; does not contribute to road congestion.	Uncomfortable; feeder service needed; rail service typically fails to serve host area; possible interference with cargo movement.	Use only as last resort.
HEAVY TRUCKS 26 foot van: 40 foot trailer:	 20 40	Fuel efficiency; flexibility.	Uncomfortable; at least half of local and intercity truck fleet will be needed for cargo movement.	Use as next-to-last resort (better than boxcars).

pending the availability of drivers and road capacity. Slightly under half of the nation's supply of trucks and more than half its boxcars should be available for passenger transportation in instances of extreme vehicle shortages.

Alternatives for controlling the use of vehicles following relocation are addressed in the Section C.3 discussion of fuel conservation measures.

A.3 Vehicle Requirements for Cargo Movement Under CRP Conditions (Guidelines)

A.3.1 Intercity Freight Movement

A summary of U.S. intercity freight movement by mode under normal conditions is shown in Table II-2. It is assumed that under crisis conditions, only essential cargo will move on the normal intercity transportation network. An evaluation of cargo movement by mode on an intercity and local basis under both normal and crisis conditions should be carried out by the crisis relocation planner. A comparison of normal and crisis intercity freight movement may be made by comparing -- on a commodity-by-commodity basis -- goods carried under normal and crisis conditions based on a national essential industries list or other similar list. In an attempt to estimate the magnitude of non-essential cargo movement, several studies were reviewed. The list of essential industries primarily used for guidance in this study was that contained in the Institute of Defense Analysis (IDA) publication, "Analysis and Identification of Nationally Essential Industries."[A-11] The IDA Nationally Essential Industries list was developed from the Stanford Industrial Classification (SIC) code numbers (see Appendix A.1-4). The following groups of commodities and industries have been included in the Essential Industries category as a basis for distinguishing between essential and non-essential commodities for intercity freight movement priority selection:

- All industrial sectors related to the production of food. There are certain exceptions, notably production of foods with little nutritional value (e.g., candy, carbonated soft drinks).
- All energy producing industries (electric power, generating facilities, petroleum refineries).
- Pulp and paper mills and selected paper products.
- Chemicals, pharmeceutical preparations, biological products, medical chemicals and botanical products, soaps and detergents, fertilizers, agricultural pesticides and chemicals.
- Tires and inner tubes, rubber and plastic hosing and belting.
- Glass containers.
- Basic steel and steel pipe.
- Selected hand tools.
- Farm machinery and equipment, construction machinery and equipment, selected power tools.
- Health supplies and equipment.
- Transport facilities, communications facilities, energy transmission and distribution.

Based on an evaluation of the IDA detailed listing of Nationally Essential Industries, the commodities listed (according to shipper group and class) in the Census of Transportation, 1967 Commodity Survey,[A10] were classified as essential or non-essential. In some cases, it was necessary to split shipper groups into individual classes to make the appropriate classifications of essential and non-essential products.

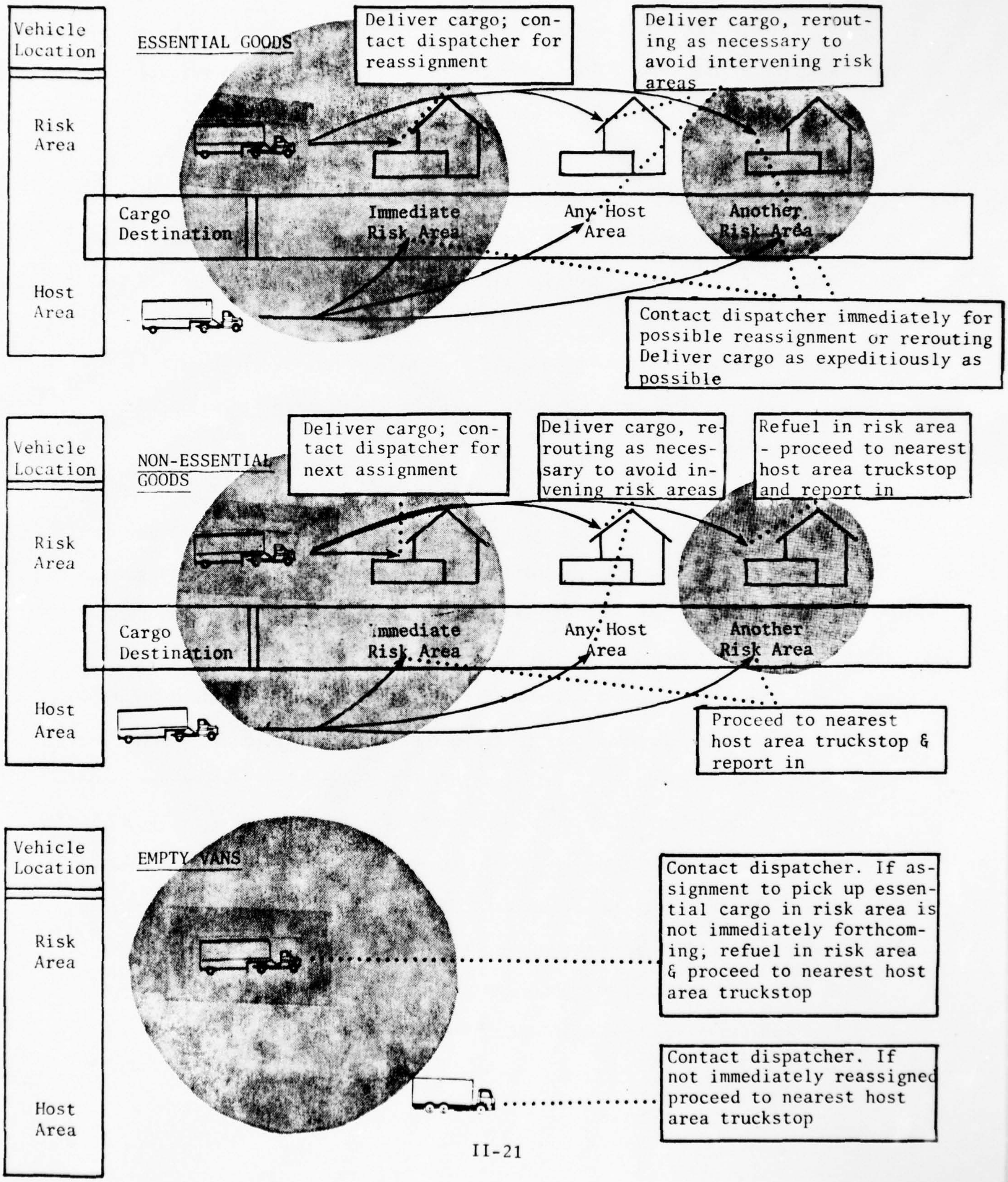
Based on the procedure described above, it was determined that approximately 63.3 percent of the intercity truck tonnage and 69.4 percent of the intercity rail tonnage consisted of essential cargo, as shown in Table II-4. In obtaining these figures, it is assumed that all essential industries will operate at normal capacity, even under crisis conditions. An alternative assumptions was made that some of the critical industries would be operating at capacity and some at 60 percent capacity. The results of this analysis are also shown in Table II-4.

A.3.1.1 Disposition of Essential Intercity Shipments. Exhibit II-4 outlines basic rules for the disposition of intercity cargo vehicles under crisis relocation conditions. Drivers carrying essential intercity cargo destined for a risk area should proceed to deliver the cargo to its destination if they are within that risk area at the time the relocation is ordered. They should then contact their system dispatcher for their next assignment. The dispatcher should be in communication with the motor transport coordinator of the transport agency responsible for coordinating risk-area cargo movement during the relocation. If no reassignment is immediately forthcoming, the driver should refuel and take his vehicle to the nearest host-area truckstop to await reassignment. Under no circumstances should a driver attempt to lay over within a risk area, even if that risk area contains his own home terminal.

Intercity drivers carrying essential shipments destined for risk areas who are outside that risk area at the time of relocation should contact their dispatcher immediately for information regarding possible reassignment or

EXHIBIT II-4

DISPOSITION OF INTERCITY CARGO VEHICLES UNDER CRISIS RELOCATION CONDITIONS



rerouting of that cargo. Delivery of most essential shipments should proceed as expeditiously as possible. In some cases, however, shipments may be reassigned from risk areas to host areas, or it may be necessary to reroute traffic around intervening risk areas.

Drivers with essential cargo destined for host-area locations should proceed to deliver that cargo, rerouting as necessary to avoid passing through intervening risk areas. Intercity drivers with empty vans laying over in risk areas at the time of relocation should contact their dispatchers and, if an immediate assignment to pick up an essential cargo within the risk area is not forthcoming, refuel and proceed to the nearest host-area truckstop to await reassignment.

A.3.1.2 Disposition of Non-Essential Intercity Shipments. No shipments of non-essential goods should be initiated once the relocation order is given. Of those shipments on the road at the time the order is given, the only non-essential shipments to be delivered should be those destined for host areas and those already inside that risk area which serves as their final destination. All other drivers hauling non-essential goods should proceed to the nearest host-area truckstop and report to their dispatcher. There the trailer and its cargo will generally be stored while the driver and power unit may be reassigned to supplement local or intercity transportation requirements. In some emergency situations, the cargo may be off-loaded to free the entire vehicle, but such instances will presumably be rare during the relocation period, as few shortages of intercity carriers are anticipated, and only an estimated 10 percent of all truckstops have warehouse facilities on-site.

TABLE II-4

SUMMARY OF TRUCK AND RAIL INTERCITY SHIPMENTS, 1967

(IN TONS AND TON-MILES)

	VOLUME (000 TONS)				TON-MILES (MILLIONS)			
CATEGORY	Motor Carrier	Private Truck	Total Truck	Rail	Motor Carrier	Private Truck	Total Truck	Rail
VOLUME (000 Tons)								
Normal Conditions	369,402	190,892	560,294	454,460	99,696	28,997	128,693	250,126
Crisis Conditions (all essential industrial plants operating)	238,894	115,811	354,705	315,532	63,126	16,782	79,908	102,561
Certain Plants Operating at 60% Capacity	86,219	99,062	285,281	241,052	48,415	14,041	62,456	75,270
PERCENTAGE SHARE OF NORMAL CONDITIONS								
Normal Conditions	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Crisis Conditions (all essential industrial plants operating)	64.7%	60.7%	63.3%	69.4%	63.3%	57.9%	62.1%	41.0%
Certain Plants Operating at 60% Capacity	50.4%	51.9%	5 .9%	53.0%	48.6%	48.4%	48.5%	30.1%

Sources: Census of Transportation, 1967 Commodity Transportation Survey, U.S. Bureau of the Census, Washington, D.C., pages 5-105; and SYSTAN Analysis.

TABLE II-5

PERCENTAGE DISTRIBUTION OF TRUCK TRIPS PER DAY BY COMMODITY AND TRUCK CLASS IN URBAN AREAS

COMMODITY GROUP	LIGHT	MEDIUM	HEAVY	TOTAL
"NORMAL CONDITIONS"				
PRODUCTS				
Food and Farm Products	23.1	44.7	12.6	28.2
Pulp and Paper Products	1.6	2.0	2.7	1.7
Chemicals, Petroleum, Coal	3.4	6.7	12.0	4.6
Manufactured Items	16.2	12.3	20.0	15.1
Scrap and Waste	0.9	8.5	14.0	3.5
Subtotal	45.2	74.2	61.3	53.1
TOOLS, EQUIPMENT, MISC.	28.2	12.6	12.2	22.7
EMPTY	26.6	13.2	26.5	24.2
ALL COMMODITIES	100.0	100.0	100.0	100.0
CRISIS CONDITIONS				
PRODUCTS				
Food and Farm Products	23.1	44.7	12.6	28.2
Pulp and Paper Products	1.6	2.0	2.7	1.7
Chemicals, Petroleum, Coal	3.4	6.7	12.0	4.6
Manufactured Items	0	0	0	0
Scrap and Waste	0.9	8.5	14.0	3.5
Subtotal	29.0	61.9	41.3	38.0
TOOLS, EQUIPMENT, MISC.[1]	8.3	3.7	3.6	6.8
EMPTY [2]	6.9	3.7	6.9	6.0
	44.2	69.3	51.8	50.8

NOTE: 1) Estimated to be 30% of "Normal"

2) Estimated to be 25% of "Normal"

Sources: Motor Trucks in the Metropolis, Wilbur Smith and Associates, New Haven Connecticut, under Commission from the Automobile Manufacturers Association, August 1969, pp. 42 and 184.

SYSTAN analysis

A.3.2 Urban Freight Movement

If data on urban truck trips or vehicle-miles is available, it may be used, along with cargo vehicle inventory data, to calculate cargo movement within the city (risk area) under "normal" and crisis relocation. This may be done as illustrated in Table II-5. If data is available in the detail shown in Table II-5, it will be possible to estimate goods carried and excess capacity under "normal" and crisis relocation conditions. In the event that cargo trip data is not available for a given risk and host area, data obtained in studies of other cities may prove useful. Table II-5 shows the percentage of truck trips by commodity and truck class in eleven urban areas. The first part of the table shows truck trips under normal conditions, and the second shows truck trips under crisis conditions. The second part of the table shows that the total volume of commodities handled (or trips) within the risk area could be reduced by an estimated 50 percent. Estimates of essential cargo or product categories were based on the local vital facilities analysis and lists of the Institute for Defense Analysis discussed above.[A-11,12] In brief, local essential industries and products have been defined as those which input to the production of food, certain wholesale functions pertaining to the distribution of food, drugs and other vital items, those producing energy (e.g., petroleum refining), transport, communications, electric power, gas and sanitary services, certain paper industries, chemicals (fertilizers and medicines), and motor vehicles and accessories. Of course, what might be classified as a local vital facility in one area may not exist in another. For example, the manufacturing of transport equipment may be a major activity in one risk area and a minor or non-existent

one in another. Such information may be obtained from the Census of Manufacturing,[10] which provides manufacturing data on a state and county level for the United States. Table II-6 provides a summary comparison of intercity and urban freight movement under normal and crisis relocation conditions. The foregoing discussion relates calculations of volume of cargo carried and capacity available before relocation and after relocation. (In this study, the volume for the "during relocation" period was assumed to be the average of that before and after relocation.)

A.3.3 Movement of Critical Vehicles and Assembly of Parts Inventories in the Host Area During Crisis Relocation

A.3.3.1 Movement of Critical Vehicles. Earlier studies have disclosed that much of the critical rolling stock, such as switch engines and debris-removal equipment, in the risk area at the time of an attack were damaged or inaccessible due to debris blockage in the immediate postattack period. Due to their concentration in railroad classification yards, switch engines will have a lower survival rate than line locomotives and freight-cars. Switch engines, as well as debris-removal and track repair equipment, will be urgently needed in the postattack period, and plans should therefore be made to move as much of this equipment as possible out of the risk area during the crisis relocation period without disrupting the orderly flow of necessary work. Interviews with railroad officials should be undertaken to determine (1) average level rolling stock in the yards at any one time, (2) probable rolling stock to be moved out during the crisis relocation period, and (3) suitable host area locations for siting critical rolling stock. The latter item will be discussed further in Subsection B (Roads). In addition, specialized motor vehicles (e.g., ambulances, dump

trucks, and debris removal equipment, should be moved to the host area during relocation to the extent that this is possible without disrupting risk area operations; similar planning procedures should be applied in the case of these vehicles.

A.3.3.2 Assembly of Parts Inventories in Host Areas. Locomotive spare parts and maintenance manuals should also be moved to the host area during the crisis relocation period. Parts for trucks and other critical motor vehicles should also be moved to the host area. Information on probable availability of railroad freight-cars during a crisis relocation period can be obtained from railroad officials; the probable availability, of course, will vary from one risk area to another. Cargo vehicles generally have excess outbound capacity, and can readily carry vehicle parts and other critical items. Identifying which types of parts should be moved, locating them, estimating the quantities involved and arranging for their transfer should also be part of the planning process and included in the Transportation Annex.

A.3.4 Increased Transportation System Stress

Under crisis relocation conditions, intercity freight movements via both truck and rail should follow normal patterns as closely as possible, except that shipments should be limited to critical commodities. As discussed above, this should result in a savings of roughly 40% of normal intercity truck movements and 60% of normal intercity rail movements. Local distribution patterns will be similarly limited to the movement of critical commodities. In this case, the total number of commodities handled within the risk area will be reduced by an estimated 50%, but the distance traversed in moving

TABLE II-6

SUMMARY OF CARGO MOVEMENTS
UNDER NORMAL AND CRISIS CONDITION

		CRISIS CONDITIONS AS PERCENT OF NORMAL CONDITIONS
U.S. INTERCITY TRUCK FREIGHT MOVEMENTS (millions of ton miles per year; nationwide)		
NORMAL CONDITIONS	128,693	62.1%
CRISIS CONDITIONS	79,908	
U.S. INTERCITY RAIL FREIGHT MOVEMENTS (millions of ton miles per year; nationwide)		
NORMAL CONDITIONS	250,126	41.0%
CRISIS CONDITIONS	102,561	
URBAN TRUCK TRIPS (thousands of trips per day; eleven composite cities)		
NORMAL CONDITIONS	913.9	51.0%
CRISIS CONDITIONS	465.7	

such critical supplies as food and fuel from the risk to the host areas will be significantly increased. Thus, the transportation stress imposed by a crisis relocation strategy upon the freight transportation system will primarily be borne by local distribution trucks. The distance traversed by these trucks in proceeding from risk area warehouses and storage terminals to host area distribution points will increase considerably over the distance normally traveled in local distribution within the risk area.

Past studies of critical goods movement under crisis relocation conditions[A-13,14] have led to the development of mathematical models capable of providing more precise estimates of the increase in local truck travel imposed by a strategy of crisis relocation. These models have been used to estimate the increases in vehicle mileage and time imposed on the food distribution system by crisis relocations in several cities and states. The results of this work, documented in detail in an earlier SYSTAN study,[A-13] are summarized in Table II-7.

As defined in Table II-7, the transportation stress factor estimated using the network model represents the ratio of the vehicle mileage required to support crisis relocation to the vehicle mileage incurred under normal operating conditions. Thus, a stress factor of 1.50 reflects a 50% increase in vehicle mileage under crisis relocation conditions. Table II-7 shows that the regionwide transportation stress factor exceeds 2.0 (i.e., vehicle mileage requirements double) in the case of only one of the five regions studied. In this single case, which encompassed the State of Colorado, long evacuation

TABLE II-7

COMPARISON OF LOCAL TRANSPORTATION STRESS FACTORS FOR THE FOOD DISTRIBUTION SYSTEMS OF FIVE AREAS

REGION OR METROPOLITAN AREA	LOCATION OF MAJOR FOOD WHOLESALERS	VEHICLE MILEAGE STRESS FACTORS		
		Total Region	Least Stressed Wholesaler	Least Stressed Wholesaler
Detroit	Detroit	1.92	1.20	2.62
San Jose	San Francisco, Oakland	1.18	1.11	1.56
Richmond	Richmond, Washington, D.C.	1.50	1.07	1.92
Colorado Springs	Denver, Pueblo	1.75	1.58	2.92
State of Colorado	Denver, Pueblo, Grand Junction	3.04	1.46	7.45

NOTE: Transportation Stress Factor =

$$\frac{\text{Vehicle Mileage Under Crisis Relocation Conditions}}{\text{Normal Vehicle Mileage}}$$

Source: Reference A-13

distances coupled with a heavy concentration of normal business in the Denver metropolitan area caused vehicle mileage requirements to triple under crisis relocation conditions.

Table II-7 also displays the transportation stress factors associated with the individual wholesalers undergoing minimum and maximum stress in each of the study areas. In general, the greatest transportation stress was imposed on wholesalers serving a heavy concentration of risk area retail outlets, while wholesalers whose normal range of operation encompassed host area retail outlets experienced minimum amounts of stress.

A.3.5 Alternative Measures to Ease Transportation Stress

As part of earlier studies,[A-13,14,15] distribution managers for major food wholesalers serving each of the areas indicated in Table II-7 were interviewed at some length regarding potential measures that might be employed to ease the transportation stress imposed on the food distribution system by a crisis relocation. Similar interviews were carried out in the case of motor fuel distributors serving Colorado Springs. Most of the distribution managers interviewed felt that the vehicle mileage covered by their truck fleets in making local deliveries could be doubled under emergency conditions; additional increases would require additional equipment. The larger food distributors interviewed indicated a willingness to lease additional equipment in time of emergency. This is their current practice when demand surges render their truck fleets inadequate. Many gasoline distributors rely heavily upon public carriers under normal circumstances and would follow this

strategy instinctively during an emergency. Additional strategies for increasing truck and driver productivity include:

(A) RELAXING REGULATORY CONSTRAINTS

   i. Relaxing union and DOT driver restrictions

   ii. Ignoring over-the-road weight limitations

(B) IMPROVING UTILIZATION OF EXISTING EQUIPMENT

   i. Relaxing maintenance requirements

   ii. Minimizing down-time

   iii. Shipping only full-pallet loads of commodities

   iv. Eliminating light loads

   v. Shipping only necessary commodities

(C) OBTAINING ADDITIONAL EQUIPMENT AND DRIVERS

   i. Leasing equipment

   ii. Using in-coming equipment from manufacturers

   iii. Commandeering additional drivers and equipment from less critical sectors of the economy

Each of these strategies, which were originally proposed in SYSTAN's study of food distribution,[A-13] is discussed briefly in the following paragraphs.

(A) RELAXING REGULATORY CONSTRAINTS. Most distribution chiefs interviewed felt that the availability of trained drivers would be a more important consideration under conditions of crisis relocation than the availability of trucks and trailers. Union regulations vary throughout the country, but they generally follow Department of Transportation guidelines, which currently restrict drivers to ten hours of driving in a fifteen-hour tour of duty. Relaxation of these rules would ease the problem of supplying evacuees slightly. However, safety considerations clearly limit the amount of additional driving time that might be attempted within a single tour of duty. Thus, twelve hours of driving during a single sixteen-hour tour of duty might represent an acceptable extension of the current limits, but no driver should attempt to drive for the full tour of duty.

Relaxation of current regulatory restrictions would also ease the task of scheduling drivers on the longer runs required under crisis relocation conditions. Even assuming that restrictions are relaxed, additional drivers will undoubtedly have to be obtained from local Teamsters unions if the number of vehicle-miles needed to supply the population doubles (i.e., if the transportation stress factor approaches 2). One executive estimated that a doubling of truck mileage could only be achieved by a 33 percent increase in drivers, even assuming that union regulations were relaxed.

Many states impose weight limitations on trucks traversing the state's highways. The waiving of these limits under crisis relocation conditions

would improve vehicle utilization. Since weight limits vary from state to state and many full truckloads of food do not approach these limits, it is difficult to assess the extent of this improvement. The actual increase in shipment weight resulting from the relaxation of weight restrictions depends both on truck size and on product density. However, it is unlikely that the increase in allowed shipment weight would represent more than 25% of the original load. In general, moreover, the density of food products is such that only truckloads of certain dry groceries might be increased by a relaxation of weight limitations. Since dry groceries comprise 31% of all truckloads shipped by food wholesalers, an upper limit on the overall improvement in truck utilization likely to result from a relaxation of weight restrictions is 7.8% (a 25% improvement in 31% of the cases). Relaxation of weight restrictions is not likely to effect significant improvements in the efficiency of tank truck utilization for fuel movement.

(B) IMPROVING THE UTILIZATION OF EXISTING EQUIPMENT. Most company executives interviewed felt that their existing equipment was under-utilized and that elimination of slack in the current vehicle schedules would permit a doubling of vehicle mileage under emergency conditions. One company, for example, reported that its trucks are currently on the road 57 hours per week (averaging 37,000 miles per year per truck). Allowing 52 hours for maintenance, loading and servicing, some 59 hours per week (35% of available time--not atypical in the food industry) would remain for extending service to stores in areas hosting evacuees. Many tank trucks are limited to 12-hour operations under normal working conditions by the need to make fuel deliveries when gasoline stations are open and attended. Utilization of these trucks could be doubled under emergency conditions by arranging for unattended deliveries.

Additional vehicle hours could be realized by cutting back on maintenance procedures, but it was estimated that full fleet utilization would not be possible for more than two weeks if maintenance procedures were reduced. Thus, the duration of the evacuation crisis would be an important consideration.

Vehicle productivity may also be improved somewhat by reducing the time required to load trucks for local delivery. Loading times reported by food industry personnel ranged from 1-1/2 hours (a four-man crew loading a 40,000# truck destined for a single large retail outlet) to 3-1/2 hours (a three-man crew loading a 40,000# truck destined for many small retail outlets). Since brand sensitivity should be minimal under conditions of crisis relocation, the time spent at the loading dock should be considerably reduced under these conditions. Food warehouse supervisors estimated that if they could load a truck directly with pallet loads of different items, loading times might be reduced to 1/2 hour per trailer, a savings of from one to three hours over normal operating procedures. Loading and unloading times for large tank trucks are roughly one hour, and few improvements appear possible. Some efficiencies could be realized by eliminating brand and product distinctions, but this may be an undesirable action in the case of motor fuel products.

Another means of improving vehicle utilization under emergency conditions is to ship only essential items. Every retail grocery store carries many items which would not be required for survival under crisis relocation conditions. The identification of non-essential items is not simply a matter of separating food and non-food items and shipping only food items to host area outlets. While some non-food items carried by grocers are clearly not essential to survival (i.e., toys, hair spray, and tobacco products), many others

in this classification will contribute significantly to the well-being of the evacuated population (i.e., aspirin, toilet tissue, and detergents). By the same token, not all food items contribute significantly to the nutritional well-being of the population.

Exhibit II-5 contains suggested shipping guidelines for reducing non-essential grocery shipments under crisis relocation conditions. These guidelines were prepared by scanning the categories in the grocery order book of a large independent wholesale grocer and identifying those food items which would contribute to the emergency consumption standards established by the United States Department of Agriculture, as well as those non-food items which would contribute to the health, comfort, and well-being of the evacuees. The items classified as non-essential in Exhibit II-4 represent an estimated 15 percent (by volume) of the supplies normally delivered to retail food outlets. Some additional savings could be realized by eliminating certain of the less useful items within the major categories identified for shipment and by shipping the larger sizes of products packaged in different weight categories. In the event that vehicle availability is not a critical factor in a specific area, certain of the non-critical items (i.e., coffee, tea, soft drinks) identified in Exhibit II-5 should be shipped to the host area to help improve the morale of the relocatees.

(C) OBTAINING ADDITIONAL EQUIPMENT AND DRIVERS. One obvious means of coping with the transportation stress imposed on the local food and fuel distribution systems by a crisis relocation strategy is to secure the use of drivers and equipment from other, less critical sectors of the distribution

EXHIBIT II-5

SUGGESTED SHIPPING GUIDELINES FOR GROCERY WHOLESALERS

SUPPLYING HOST AREA RETAIL OUTLETS

CATEGORY	SHIP	RETAIN
Meat	All items	
Produce	All items	
Dairy products	All items	
Frozen foods	All items, as host area storage space permits	
Bakery goods	All items	
Dry groceries	Baby Foods; Baking Mixes; Baking Needs; Candy; Cereals; Cocoa; Condiments; Cookies; Crackers & Bread Products; Desserts; Diet Foods; Fish (Canned & Dried); Flour; Fruit (Canned & Dried); Household Cleaning Compounds; Jams, Jellies & Spreads; Juices & Juice Drinks; Laundry Supplies; Macaroni Products; Meat Products; Milk (Canned & Dried); Paper Products; Pet Foods; Prepared Foods; Salad Dressings; Salt, Seasonings; Shortenings & Oils; Soaps, Detergents & Disinfectants; Soup; Sugar; Syrups & Molasses; Vegetables (Canned & Dried).	Beer, Wine & Ale; Cigarettes; Coffee; Gum; Household Supplies (Furniture Polish, Shoe Polish, Air Fresheners, Floor Wax); Snacks; Soft Drinks; Tea. (Note: If vehicle availability is not critical, certain of the above items (i.e., coffee, tea, soft drinks) may be shipped as morale boosters.)
General Merchandise	Batteries; Flashlights; Light Bulbs; Anti-Freeze; Motor Oil; Twine; Sponges; Brushes; Candles; Charcoal & Charcoal Lighters; Outdoor Equipment.	Stationery & School Supplies; Lighter Fluid; Turpentine; Housewares; Lighting Accessories; Sunglasses; Toys; Grass Seed; Pet Supplies; Soft Goods (Hosiery, Gloves, Etc.).
Health & Beauty Aids	Aspirin; Baby Needs; First Aid Items; Oral Hygiene Products; Proprietary Remedies; Deodorants.	Cosmetics; Hair Care Needs; Shaving Needs; Skin Care Aids.

community. This approach is currently practiced on a small scale by most food distributors, who typically lease additional equipment when demand surges render their truck fleets inadequate. On a larger scale, many fuel distributors rely entirely on the services of leased tank cars. Under emergency conditions, additional vehicles and drivers for the movement of food and other critical products might be obtained from the household moving industry and from manufacturing firms shutting down for the duration of the crisis. In addition, trucks and drivers making deliveries from food manufacturers to wholesale distribution warehouses might be induced to make local shipments from the warehouse to the host area as part of their return journey to the manufacturer. Many manufacturers currently arrange to have their trucks backhaul other commodities on the return journey as a matter of course, so the use of these trucks in local food or fuel shipments would require an assessment of relative shipment priorities.

Since distribution managers in both the food and fuel industries agree that existing equipment is not used to capacity, it is necessary to estimate the additional usage that may be obtained from this equipment before additional drivers and equipment are obtained from other sectors of the economy. Table II-8 lists the estimated range of increases in driver and vehicle productivity associated with each of the labor- and equipment-saving measures proposed in this section. Ranges are listed for both food trucks and fuel trucks; some of the proposed measures would have the effect of increasing vehicle productivity (i.e., relaxing maintenance requirements) while other measures (i.e., relaxing union and DOT restrictions) would primarily increase driver productivity; still others (i.e., relaxing weight limitations) would improve both driver and vehicle productivity. Table II-8 shows the average potential in-

TABLE II-3

SUMMARY OF POTENTIAL PRODUCTIVITY INCREASES FOR FOOD AND FUEL TRUCKS

EMERGENCY MEASURE	ESTIMATED PERCENT INCREASE IN EFFICIENCY											
	FOOD TRUCKS						FUEL TRUCKS					
	Vehicle Time			Driver Time			Vehicle Time			Driver Time		
	Lower	Mid-Range	Upper	Lower	Mid-Range	Upper	Lower	Mid-Range	Upper	Lower	Mid-Range	Upper
REGULATORY CONSTRAINTS												
Relaxing Driver Restrictions	--	--	--	18%	20%	22%	--	--	--	18%	20%	22%
Relaxing Weight Limitations	4%	6%	8%	4%	6%	8%	--	--	--	--	--	--
EQUIPMENT USE												
Minimizing Down Time	37%	54%	71%	--	--	--	50%	75%	100%	--	--	--
Relaxing Maintenance Requirements	15%	17.5%	20%	--	--	--	5%	7%	9%	--	--	--
Eliminating Light Loads	5%	10%	15%	5%	10%	15%	0%		5%	0%	25%	5%
Shipping Only Full-Pallet Loads	5%	10%	15%	--	--	--	--	--	--	--	--	--
Shipping Only Necessary Commodities	10%	15%	20%	10%	15%	20%	--	--	--	--	--	--
TOTAL	76%	112.5%	149%	37%	51%	65%	55%	84.5%	114%	18%	22.5%	27%

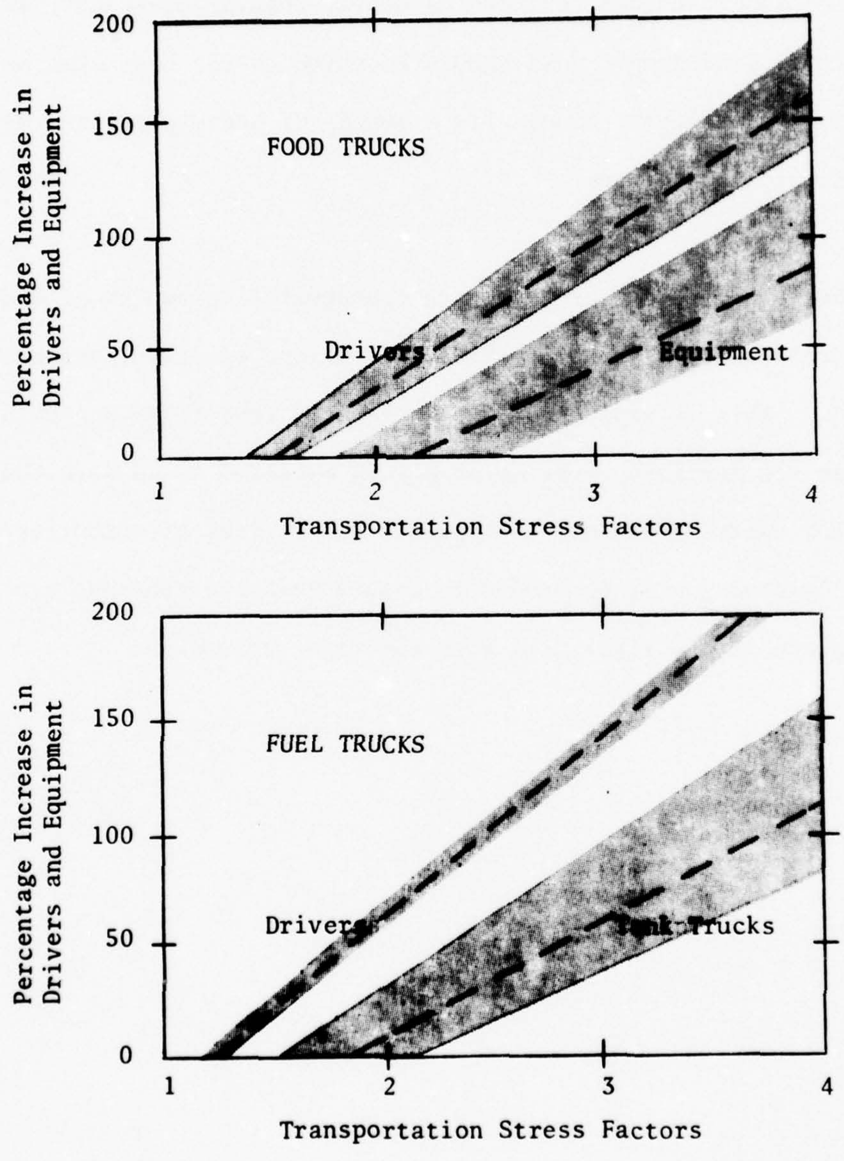
crease in driver productivity for food trucks is 51%, while the average increase in productivity possible for existing food transportation vehicles is 112.5%. This figure could range from 76% to 149%, depending primarily on existing vehicle downtime. Potential productivity increases are slightly less pronounced for fuel trucks, and depend primarily upon the relative number of trucks currently in service twenty hours per day, as opposed to more common ten- and twelve-hour operating spans. This varies from company to company.

Exhibit II-6 charts the rough results of Table II-8 as a function of different transportation stress factors. On the average, a transportation stress factor of 2.5 for food deliveries (i.e., a 150% increase in vehicle mileage) would require an influx of 18% more vehicles and 71% more drivers from other sectors of the economy. A doubling of local fuel truck mileage (i.e., a transportation stress factor of 2) would require, on the average, an 8% increase in vehicles and a 63% increase in drivers. These estimates allow for no attrition in the existing driver force in the face of emergencies, and assume that the length of the crisis relocation period will be relatively short (one to two weeks). Although Exhibit II-6 was prepared from rough estimates of the likely impact of various measures for improving distribution system productivity, it confirms two of the major intuitive observations of distribution managers regarding emergency operations under crisis relocation conditions:

(1) Driver availability is likely to be more critical than vehicle availability; that is, more additional drivers than vehicles are required to meet a specified increase in vehicle mileage.

(2) The existing distribution system can support a doubling of vehicle miles for short periods without requiring additional equipment.

Exhibit II-6: RANGE OF ADDITIONAL DRIVERS AND EQUIPMENT ASSOCIATED WITH TRANSPORTATION STRESS FACTORS



A.4 Probable Postattack Situation

Vehicle availability is not expected to be a limiting factor on the movement of goods and people following an attack. In one local study, more than twice as many trucks, buses and locomotives were expected to survive an attack following a crisis relocation strategy as were likely to survive under a strategy of in-place protection. To the extent possible, such critical vehicles as debris-removal equipment, switching locomotives, and dump trucks should be moved to the host area as part of the relocation effort, along with a supply of spare parts and maintenance manuals for all vehicles.

The most critical problem with transportation equipment under a crisis relocation strategy is likely to be one of organization and coordination. This is expected to be especially true following an attack. Although the surviving vehicle supply is expected to be more than adequate for carrying essential supplies, clear lines of authority and advance planning will be needed to ensure that the vehicles are in the right place at the right time with the right orders.

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B. ROAD AND RAIL NETWORK CAPACITY

B.1 Sources of Information

B.1.1 Top Down Approach. At the Federal level, there are several studies providing useful guidance on highway development and planning. The Highway Capacity Manual,[B1] prepared by the Highway Research Board of the National Academy of Sciences, contains guidance data on highway design, capacity, traffic control and operations, and traffic measurements. The manual also contains a number of case problems and solutions illustrating the principles outlined.

The 1974 National Transportation Report,[B2] prepared by the U.S. Department of Transportation (DOT), is another useful document providing data on state and local plans and programs, mileage trends and projections by mode, intercity and rural transport development, and various public and private transport statistics. Additional relevant Federal publications are shown in the Bibliography of this report.

At the state and local levels, a number of planning studies are regularly published on current and projected traffic flow patterns, sufficiency ratings, and highway needs. Sometimes state or regional agencies prepare highway planning documents individually, but often such studies are prepared in conjunction with DOT. The Colorado Traffic Volume Study, 1972[B3] was prepared by the Colorado State Department of Highways, Planning and Research Division, in cooperation with the Federal Highway Administration (FHWA) of DOT. This study shows total traffic volumes by highway section during a 24-hour period, 20-year expansion factors, Design Hour Volume (DHV) factors, and vehicle type.

Two pages of the 1972 Colorado Traffic Volume Study are shown for Highway 115 near Colorado Springs in Appendix Table B.1-1. A section of the 1974 Colorado State Highway Traffic Volume Map, including the Highway 115 section noted above, is shown in Exhibit II-6.1. (Sample permanent station data is shown in Appendix Table B.2.)

All states carry out sufficiency rating and needs studies. A highway sufficiency rating study is an evaluation of the existing condition of a highway or highway system and its ability to handle present traffic demands. A needs study, which indicates estimated needs cost for a specified future period, can be included as part of the same study. A sample page from the Colorado 1973 State Highway Sufficiency Rating and Needs Study[B4] is shown in Exhibit II-7, which illustrates Colorado State Highway 115 and the area around Fort Carson, Colorado. In this case, the sufficiency rating is a sum of the capacity rating, safety rating, and structural rating. A sufficiency rating of 100 indicates a road section with no deficiencies and adequate to handle current traffic. A sufficiency rating of less than 100 indicates the extent to which capacity, surface condition, and structural adequacy are deficient. The needs costs, in this case, are the estimated funds that will be necessary over the next 20-year period to adequately handle anticipated traffic demands.

Many local regions have also prepared transport planning documents alone or in conjunction with other agencies. In Colorado, the Transportation Plan for El Paso and Teller Counties, for example, was prepared by the Pikes Peak Council of Governments and the Colorado Division of Highways, in cooperation

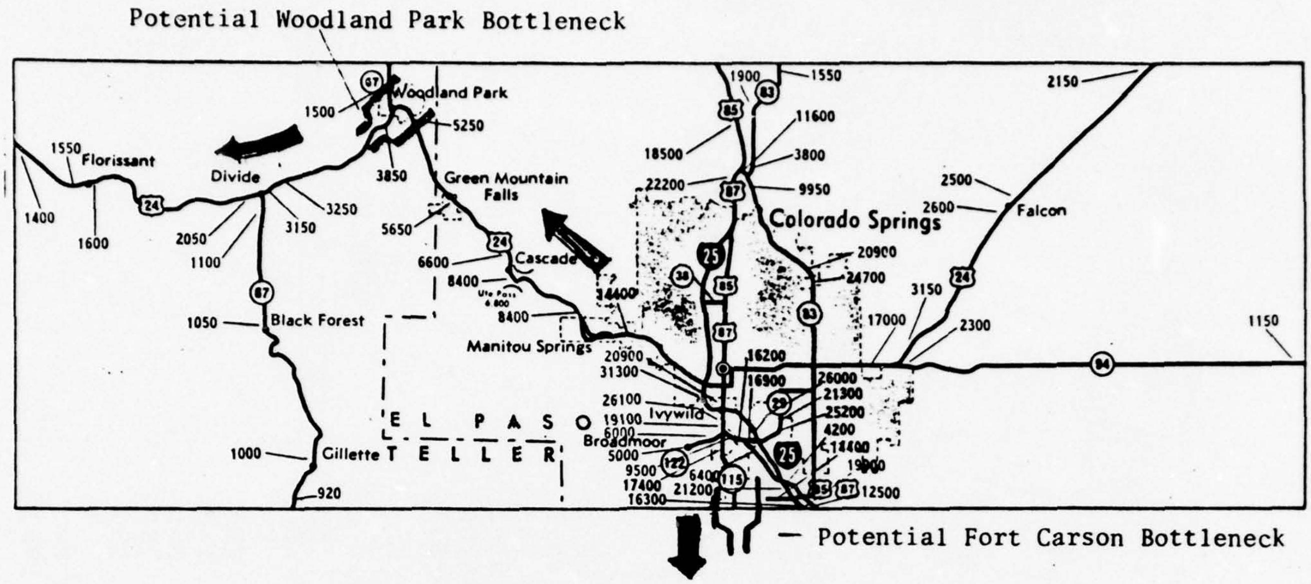


EXHIBIT II-6.1

1974 TRAFFIC VOLUMES

COLORADO SPRINGS AREA

SCALE OF MILES

0 1 2 3 4 5 10

Legend:

19100 Average Annual Daily Traffic

Designated Evacuation Route

Potential Relocation Bottleneck

Source: Colorado State Department of Highways and U.S. Department of Transportation. Colorado Traffic Volume Study, 1972.

STATE HIGHWAY 115

MILEPOINT AND AREA TYPE	31.5 R	41.3 U
LENGTH AND TERRAIN TYPE	9.8 3	4.4 1
WIDTH (PRESENT AND 20 YEAR)	44 44	68 68
PRESENT ADT	3450	19000
ADT IN 20 YEARS	5175	36100
PRESENT PSI (0-5)	3.7	3.9/3.7
-RATING-		
STRUCTURAL ADEQUACY	37	25/ 23
SAFETY	8	9/ 9
CAPACITY	50	53
SUFFICIENCY RATING	95	87/ 86
-NEEDS COST IN THOUSAND DOLLARS-		
ENGR, ROW, UTIL ADJ, + CONT.	45	226
GR, DR + MINOR STR. INCL FR + CL LANES	0	178
INTRCHNGS, BR, TNNLS, RR + HW SEPS	192	156
STAB, SURF, TRAFF CONT. INCL FR + CL LANES	0	37
RESURFACING COSTS	343	150
WIDENING COSTS	0	0
TOTAL	581	748
LAST DATE OF CONSTRUCTION	1960	1963

EXHIBIT II-7

<u>COLORADO SUFFICIENCY RATING</u>

<u>AND NEEDS</u>

with DOT.[B5] Highway needs studies are also prepared and submitted by regional governments.[B6]

A 1976 series of statewide rail system diagrams for each state showing ownership, present status and possible future abandonment of certain segments may be obtained from the Interstate Commerce Commission.[B7] Such maps and the accompanying data would be of assistance in planning the siting of critical rolling stock.

B.1.2 Bottom Up Approach. At the state level, discussions with the Highway Department will provide information on highway capacity, evacuation routes and other useful data. State highway officials, with their knowledge of the state highway system, can often provide valuable information on current bottlenecks on rural evacuation routes and freeways. An example of such a potential evacuation bottleneck is shown in Exhibit II-6 (Fort Carson, Colorado).

At the local level, it is also important to identify current and potential bottlenecks and alternative flow patterns in discussions with city and county engineers. Existing surveys may also be helpful in this regard.[B8]

Discussions with railroad officials will be essential in identifying key host-area railroad terminal and planning for their expansion. Such plans and locations should be included in the Transportation Annex plans. An example of a listing of such terminal locations is shown in Appendix B.

B.2 Planning Guidelines and Procedures

Crisis relocation requires the evacuation of a large number of people from an area considered to be unsafe to designated host areas in a short span of time under emergency conditions. Such a movement poses several problems

related to the capacity of the road network. The capacity of the regional road network has been economically designed to accommodate much lower traffic volumes and is likely to be severely taxed during a crisis relocation.

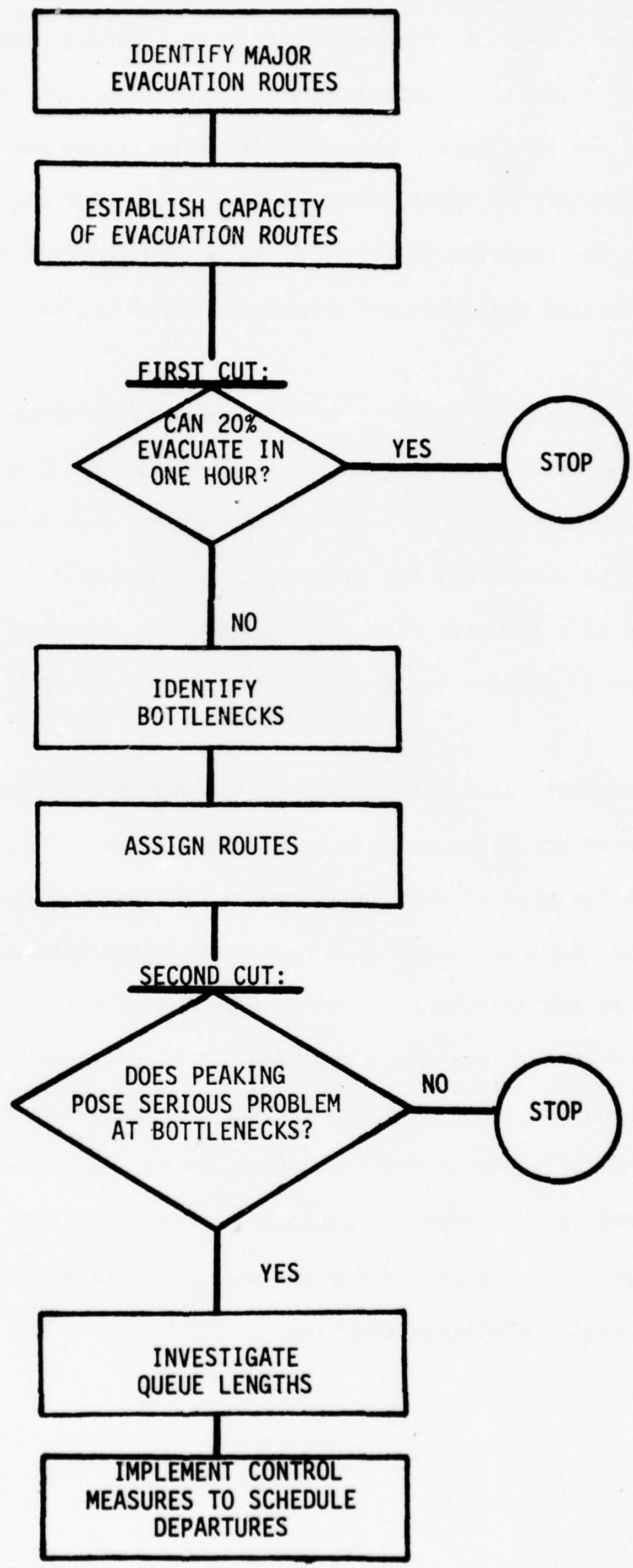
In the absence of an effective planning effort aimed at alleviating these problems, mass congestion will inevitably develop threatening the success of the relocation. Hence, the success of the relocation strategy will depend to a great extent on the ability of relocation planners to utilize the capacity of the local evacuation road network efficiently.

To do this, several planning guidelines and procedures have been developed for establishing the capacity of promising evacuation routes, identifying potential bottlenecks, assigning vehicles to certain routes to maximize outbound flow, and scheduling vehicle departures to minimize congestion.

Exhibit II-8 presents a flowchart of the approach to implementing these procedures; each step is described in the following sections. The discussion is cast in general terms, providing guidance for crisis relocation planners in any potential risk area. The first two steps consist of identifying the major evacuation routes and establishing capacities of these routes under evacuation conditions. At this point, if it appears that evacuation routes are capable of supporting 20% of the total evacuees in one hour, the road capacity is adequate and there is no need to perform a detailed analysis. However, this is not likely to be the case in most situations, and the analyst is advised to continue identifying the bottleneck locations and assigning evacuees to routes to maximize outbound flow. As a second cut, the planner should continue the analysis if excessive traffic queueing resulting from peaking in the departure patterns poses a serious problem at the bottleneck locations. This involves investigating the queue lengths and examining alternative control measures to schedule departures uniformly.

EXHIBIT II-8

FLOW CHART OF THE ROAD CAPACITY PLANNING PROCEDURE



B.2.1 Evacuation Route Capacity Planning Factors

The first step in the road capacity utilization planning procedure is to identify the major evacuation routes linking the risk area and the primary cities in the host area. This includes identifying the general type of road, the number of lanes, accessibility, and other significant features affecting the capacity of each evacuation route. This can be done by examining detailed road maps and consulting local traffic engineers.

The next step is to establish the capacity of these roads under evacuation conditions. Some general guidelines and planning factors for accomplishing this are given below. It should be emphasized that this general guidance is not meant to substitute for the practical experience of the local traffic officials in a specific risk area. The Highway Capacity Manual[B-1] is a valuable source of information for the determination of road capacities.

The capacity of a road is defined as the maximum number of vehicles that can traverse any given point over a specified period of time. Capacities vary with the type of road and geometric design, and are typically expressed as vehicles per hour under uniform uninterrupted flow conditions. For the purposes of determining the maximal flow out of a risk area during a crisis relocation without causing congestion, it is necessary to define the capacity of an evacuation route as the minimum flow over the entire route, suitably adjusted to allow for non-uniform flow due to peaking and flow interruptions (i.e., vehicle breakdowns or accidents). The possibility of severe congestion on evacuation routes argues for the use of extremely conservative safety factors in crisis relocation planning.

B.2.2 Bottleneck Identification Procedure

A fundamental crisis relocation problem is the identification of constraining points in the evacuation routes where congestion is likely to develop. The maximum rate of flow out of the risk area in terms of vehicles per hour is limited by the road capacities at these points; hence, the identification of these bottlenecks is equivalent to solving for the maximal flow rate of vehicles out of the risk area.

Although the purpose of this procedure is to identify potential bottlenecks, it will also indicate how long it will take to completely evacuate the risk area. The planning guidelines include safety factors designed to allow for interruptions and peaking in evacuation flow. Previous studies have assumed uniform uninterrupted flow of traffic out of the risk area. For several reasons discussed in the previous section, the assumption of uniform, uninterrupted flow is invalid for determining the evacuation time in emergency situations.

If the solution to this problem indicates that it is not possible to clear the risk area in 72 hours, a serious problem exists and methods of utilizing the available capacity more efficiently must be considered. These alternatives may include the use of contra-flow lanes or additional routes, and/or host areas that were previously considered unavailable due to conflicts with the relocation of neighboring risk areas. Regardless of whether or not a congestion problem exists, a sensitivity analysis can be performed to estimate the value of alternative methods of increasing the evacuation capacity or utilizing it more efficiently.

Capacities for different types of roads under ideal uninterrupted flow conditions are listed in Exhibit II-9. Maximum volumes for free flow conditions are also given with the corresponding speeds at which vehicles travel under these conditions. These figures were taken from the Highway Capacity Manual[B-1] and provide estimates of the capacities for various types of roads, but these values may vary depending on the geometric design of a specific road. Hence, it would be desirable to consult a local traffic engineer and the Highway Capacity Manual before applying them in this planning procedure. As shown in Exhibit II.9, the one-way flow capacity for two-lane undivided rural roads is typically 1,200 vehicles per hour. The speed at which this volume will be attained is approximately 30 miles per hour. For the same type of road, free-flow conditions at 45 miles per hour can be maintained for volumes less than 400 vehicles per hour. Capacities are twice as high for divided rural highways with two or more lanes in each direction. In this case, the Highway Capacity Manual indicates a maximum flow volume of of 2,000 vehicles per lane per hour under uninterrupted conditions. Road capacities are highest on multi-lane divided freeways with limited access. In this case, a flow capacity of 2,400 vehicles per lane per hour should be used.

Although there is a general agreement among traffic engineers and researchers on the vehicle flow capacities of various types of roads, the appropriate use of these capacities in crisis relocation planning is poorly understood. Officially documented capacities represent the maximum attainable flows under ideal uninterrupted conditions; yet flow in emergency situations such as a crisis relocation is uncertain and confused with interruptions caused by accidents and breakdowns. It is extremely unlikely that evacuation flows can

EXHIBIT II-9 CRISIS RELOCATION ROAD CAPACITY PLANNING FACTORS

TYPE OF ROAD	FREE FLOW CONDITIONS		FORCED FLOW UNDER IDEAL UNINTERRUPTED CONDITIONS		PROBABLE UNIFORM* FLOW CAPACITY FOR A 16 HR. PERIOD (VPH/LANE)
	MAXIMUM VOLUME (VPH/LANE)	AVERAGE SPEED (m.p.h.)	CAPACITY (UPH/LANE)	SPEED (m.p.h.)	
Two-Lane Undivided Rural Roads With One Lane in Each Direction	400	45	1200	30	1000
Multi-Lane Rural Highway with Two or More Lanes in Each Direction	800	50	2000	30	1500
Multi-Lane Divided Freeway or Expressway with Limited Access	1200	55	2400	30	2000

*These factors for uniform flow should not be used to estimate traffic volumes under evacuation conditions for periods longer than 16 hours.

be maintained at capacity levels for twenty-four hours, and that evacuees can be organized to schedule their departures uniformly over a twenty-four hour day. Recognizing these problems, it is recommended that the road capacities be adjusted conservatively to allow for interruptions by incorporating a safety factor in the evacuation route capacities, and that a 16-hour "evacuation day" be used. This is not meant to suggest that no one will leave during the remaining eight hours of the day, but rather to reflect (1) the impossibility of maintaining maximum flow conditions for an uninterrupted 24-hour period, and (2) the likelihood that fewer people will leave their homes in search of lodging in the host area during these late night/early morning hours. This 16-hour day assumption alone is somewhat unsatisfactory, however, as it assumes departures will be spread evenly over 16 hours, and ignores the potential congestion resulting from an uneven distribution of flow. Hence, the capacities should be adjusted by the safety factor to allow for the impact of uneven departure rates.

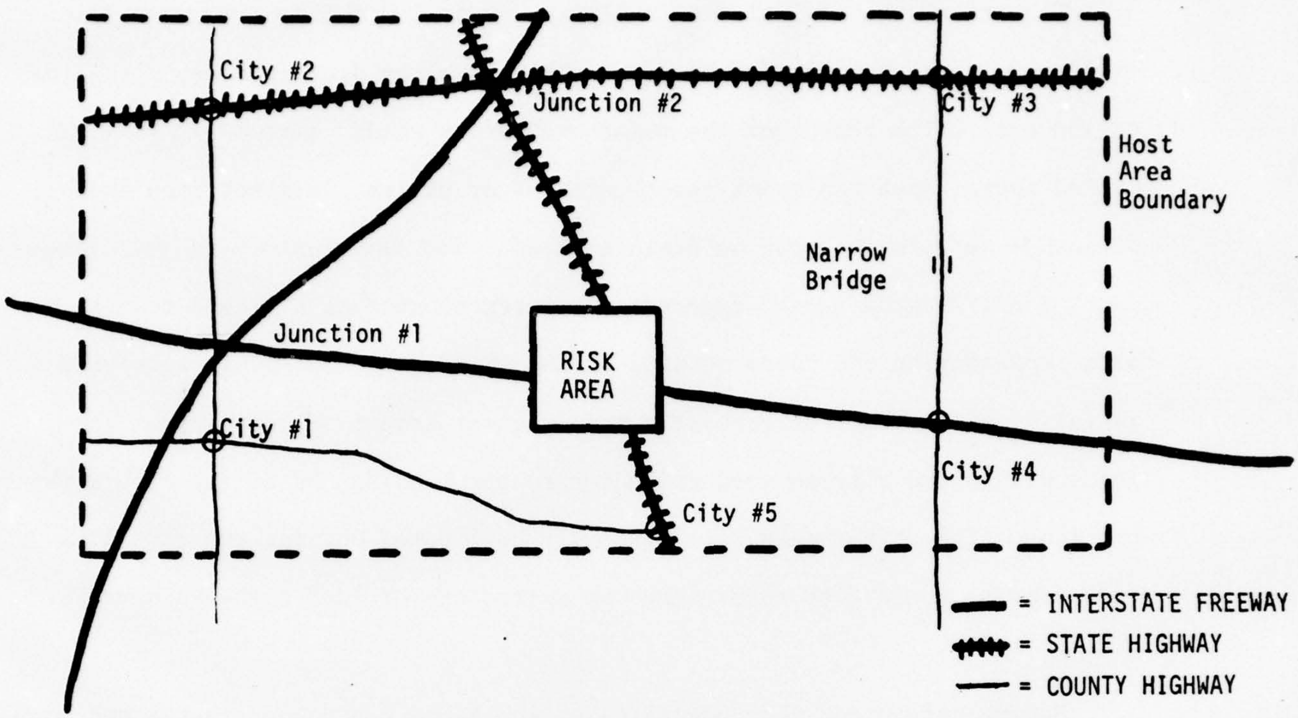
As a first cut in the road capacity planning procedures, the Risk Area Guide[B-9] published by DCPA suggest the following measure: so long as 20% of the total number of evacuees assigned to a route over the three-day evacuation period can leave within one hour without exceeding the route's capacity, there is no need to schedule departures to minimize congestion. This condition is sufficiently stringent so that it is unlikely to be met on all the evacuation routes in a risk area; that is, most risk areas will have to make some attempt to schedule departures. Where the potential effects of congestion are in doubt, the procedures presented in Section B2.4 can be employed to examine the queue lengths and delays at bottlenecks in the evacuation route resulting from different evacuation routes and peaking patterns. The procedures described in the following section provide guidance for identifying the location of these bottlenecks.

To perform the maximal flow analysis, it is helpful to represent the evacuation route network graphically. This involves drawing a map with lines called arcs which represent the major evacuation roads connecting circles called nodes which represent road junctions or cities. A simplified example of such a network is shown in Exhibit II-10. For the purposes of this procedure, the risk area may be aggregated and represented as a single node with arcs representing the roads outside of the risk area city. This aggregation is valid, since there is generally a sufficient amount of capacity on the roads within the city to feed the major routes leading out of the city without problems. The bottlenecks will typically be located outside the risk area city limits, where city roads merge or multi-lane divided highways narrow.

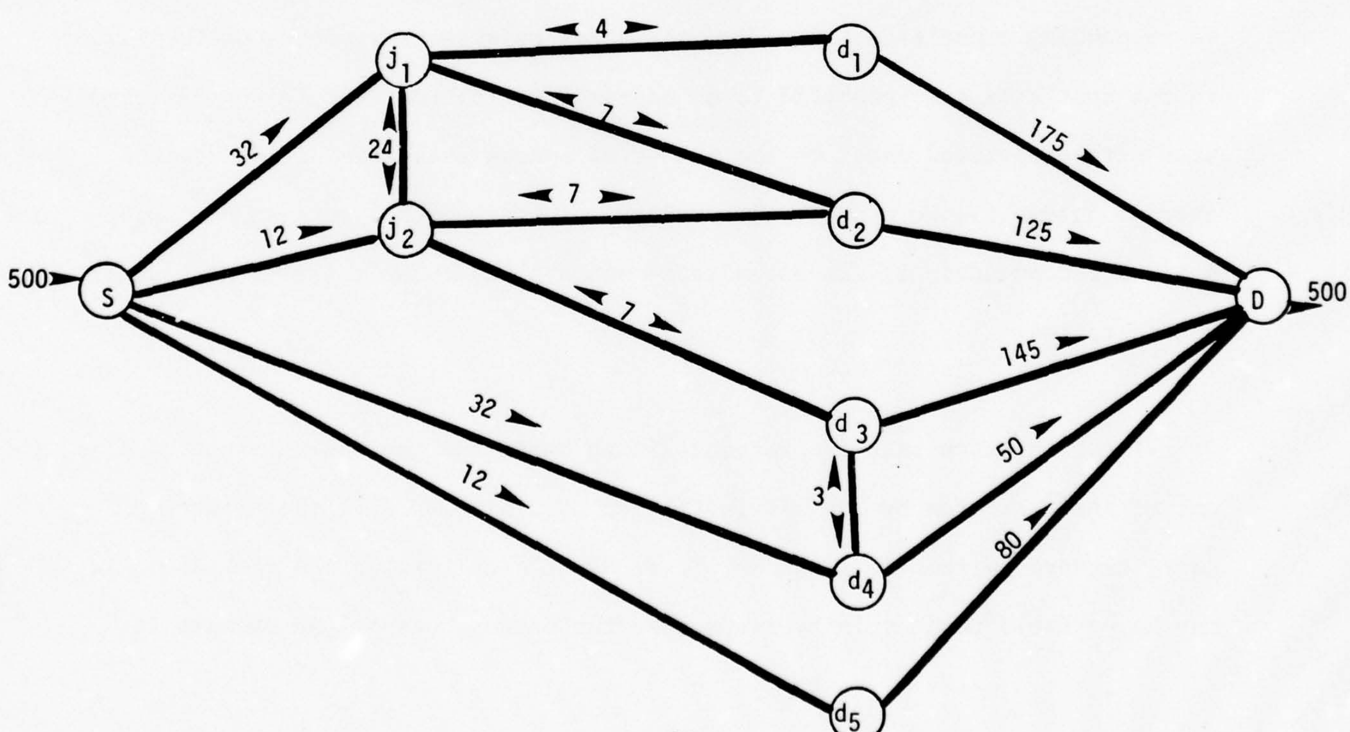
Having determined the capacities of the major evacuation routes and applied the appropriate safety factors, the graphical representation of evacuation route network can be completed. The arcs of the network are labeled with the corresponding capacities. Finally, all nodes representing cities or towns in the host area are connected to a "master" destination node, D, by directed arcs with capacities equal to the number of spaces available divided by the average automobile occupancy. An average occupancy of 3.5 persons per automobile is recommended if an estimate is not available for the risk area under consideration.

The final step in this procedure is to determine the maximal rate of flow out of the risk area by identifying the constraining arcs in the network. For small networks with a small number (2 or 3) of arcs leaving the risk area, it may be possible to do this by inspecting the network graph. An example is

EXHIBIT II-10 RISK AND HOST AREAS FOR CRISIS RELOCATION



NETWORK REPRESENTATION WITH
EVACUATION ROUTE CAPACITIES (100 cars/hour)



shown for Colorado Springs in Exhibits II-11.1, II-11.2, and II-6. Under initial evacuation plans, there were only two routes leading out of the risk area with the same one-way adjusted capacity of 700 vehicles per hour. Since the remaining arcs in the network had capacities greater than or equal to these and all vehicles must leave the risk area by one of these two routes, these two arcs constrained the rate of flow out of the risk area. Hence, the maximal flow rate is obtained by adding the capacities of these two routes, and is equal to 1,400 vehicles per hour. For this example, there are two bottleneck points, located at the points of minimum capacity along these routes (where the roads narrow from two lanes in each direction to one lane).

An estimate of the total time to evacuate the risk area completely is obtained by dividing the total number of vehicles to be evacuated from the risk area by the maximal flow rate. For the example in Exhibit II-11, the total number of vehicles to be evacuated is 37,577 and the maximal flow rate is 1,400 vehicles per hour. Hence, the total evacuation time is 26.841 hours, which will require considerably more than one day using the 16-hour day planning factor. This is much lower than the maximum allowable time of 72 hours, so it does not appear that a serious problem exists. However, it should be recognized that this time estimate assumes balanced flow on all exit routes, which may not be consistent with the availability of spaces in the host areas. The route assignment procedures in the following section may be used to check this.

In the example given above, the bottleneck points could be located by inspection of the network. This is not possible for more complicated networks in which evacuation routes merge or narrow further from the risk area; in

EXHIBIT II-11.1

MAP OF EVACUATION ROUTES
FOR COLORADO SPRINGS RISK AREA

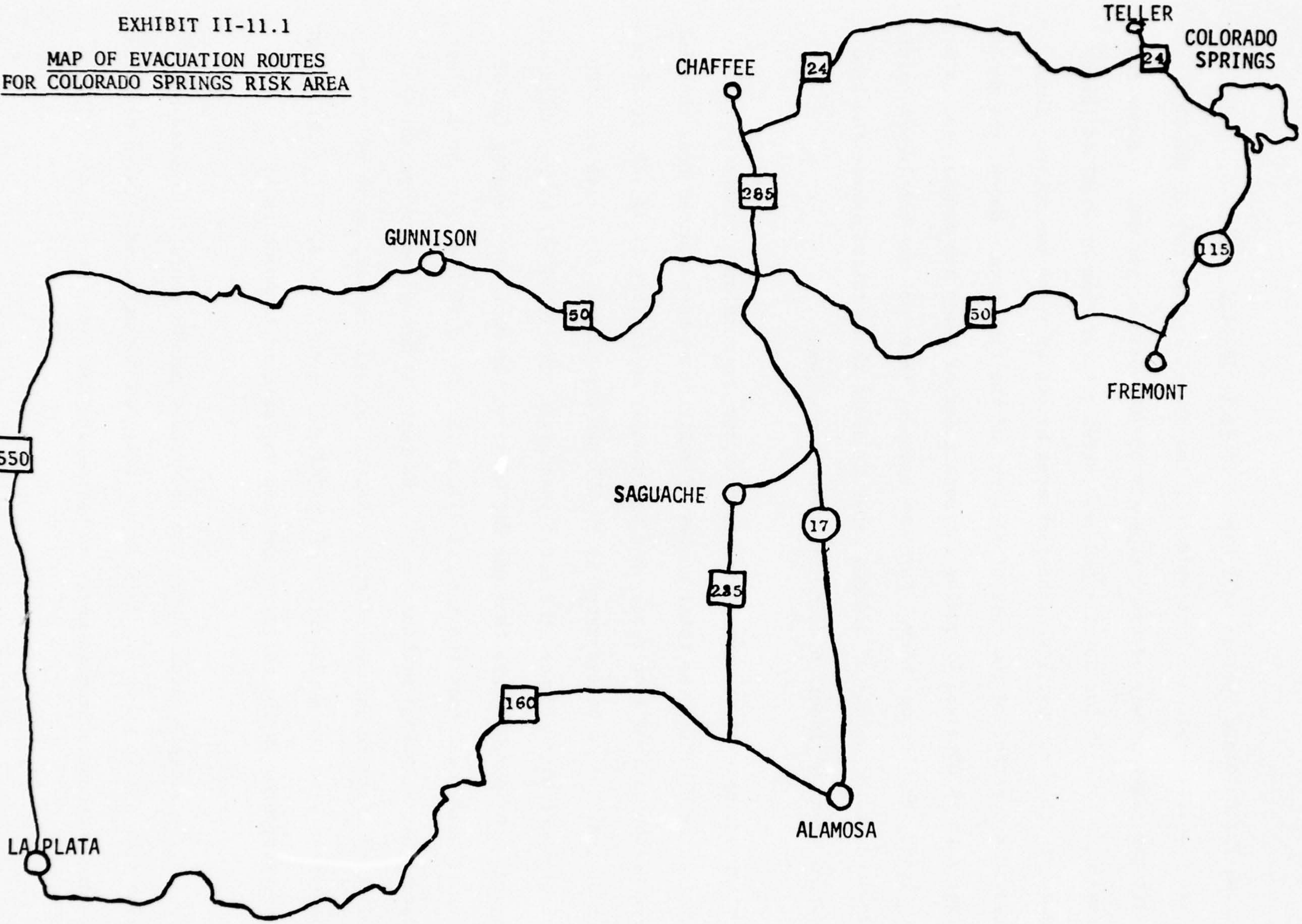
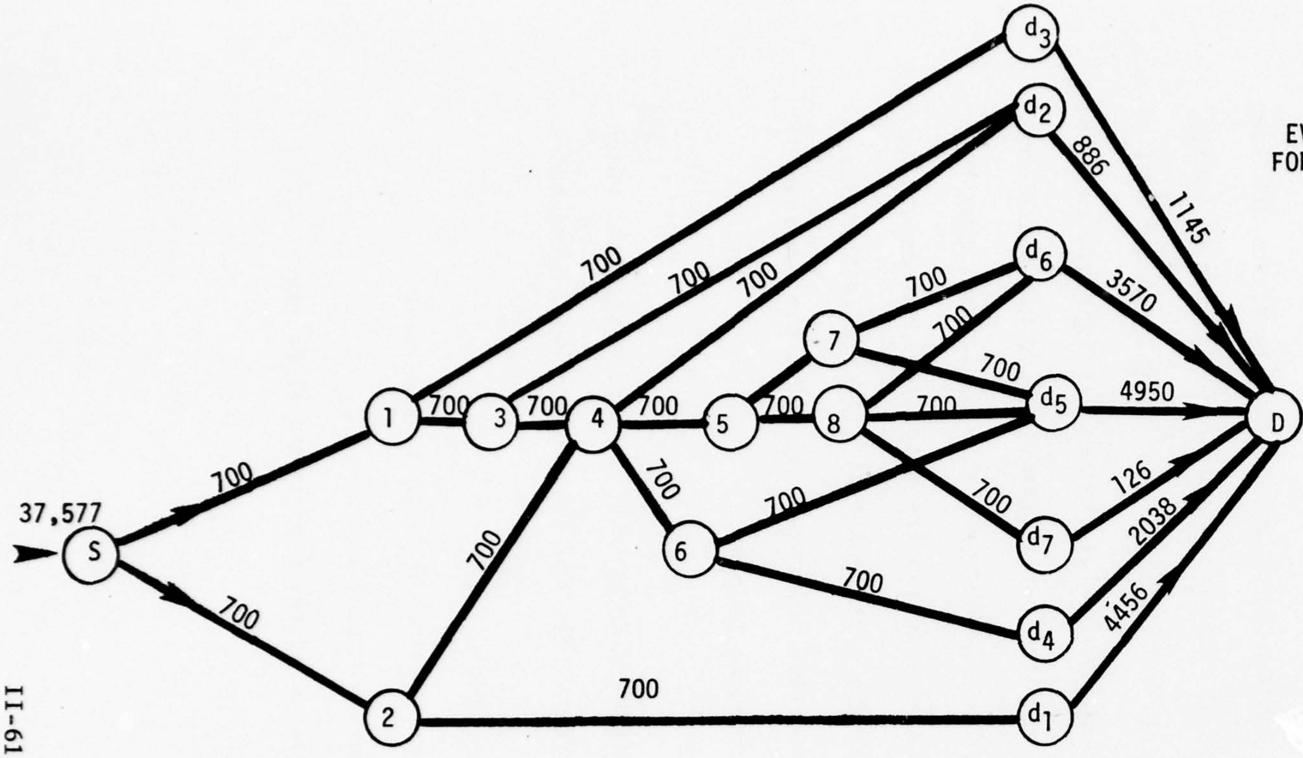


EXHIBIT II-11.2

EVACUATION ROUTE NETWORK GRAPH
FOR COLORADO SPRINGS RISK AREA



NODE	HOST AREA ZONE	SPACES AVAILABLE	VEHICLES
d_1	Fremont	15,596	4,456
d_2	Chaffee	3,103	886
d_3	Teller	4,007	1,145
d_4	Gunnison	7,134	2,038
d_5	La Plata	17,327	4,950
d_6	Alamosa	12,497	3,570
d_7	Saguache	443	126

NODE	HIGHWAY JUNCTION
1	Route 24 and 67
2	Route 115 and 50
3	Route 24 and 285
4	Route 285 and 50
5	Route 285 and 17
6	Route 50 and 550
7	Route 17 and 160
8	Route 285 and 160

ARC	EVACUATION ROUTE
S ► 1	Route 24
S ► 2	Route 115
1 ► 3	Route 24
2 ► 4	Route 50
3 ► 4	Route 285
4 ► 5	Route 285
4 ► 6	Route 50
5 ► 7	Route 17
5 ► 8	Route 235
6 ► d_5	Route 550
7 ► d_5	Route 160
8 ► d_5	Route 150

these cases, the algorithm described in Appendix B of Volume I should be used. Furthermore, the locations of the bottleneck points are very close to the risk area city limit, posing a potential problem if traffic congestion backs up from these points to the city itself. An investigation of the queue lengths using the procedures outlined in Section B.2.4 will indicate the seriousness of this problem.

B.2.3 Route Assignment Procedures

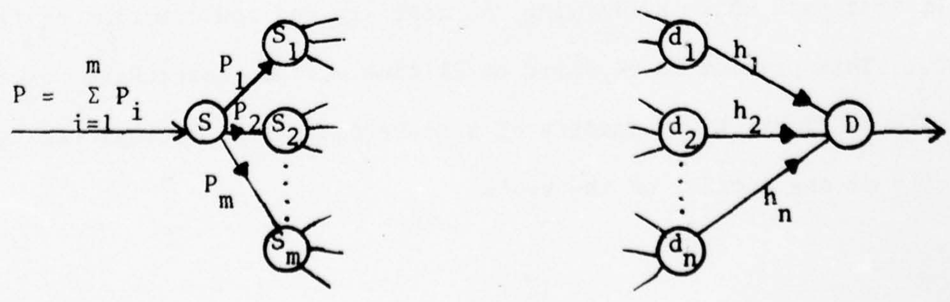
Having determined the flow capacities of the evacuation routes and identified the bottleneck points, it is necessary to assign evacuees to routes so that the relocation can proceed with a minimum of congestion and confusion. Many combinations of routes and the number of evacuees assigned to each one need to be considered in order to find the assignment which minimizes congestion and total evacuation time. Furthermore, this assignment must be consistent with the availability of space in the host areas corresponding to each evacuation route. Probably the most important criteria is that the assignment should be easily understood and communicated to the evacuees if the evacuation is to proceed according to plan.

A planning procedure was developed to provide a route assignment which satisfies these criteria. The four steps of this process are listed below:

1. Divide risk area into population zones;
2. Determine number of spaces available in host area zones;
3. Construct evacuation route network; and
4. Assign evacuees to routes using the assignment algorithm.

The first step consists of dividing the risk area into population zones which are easily identified and understood by the evacuees. Telephone prefixes or census tracts appear to provide the most promising basis to accomplish this; they are small enough so everyone living in the same zone can be instructed to evacuate on the same route. The number of people living in each of these zones can be determined from the most recent census data for the risk area. An assignment based on telephone prefix zones is easily communicated to evacuees, since nearly everyone has a telephone and knows his telephone prefix number. Furthermore, the geographic boundaries of telephone prefix zones can be obtained easily from the local telephone company.

The next step--if it has not already been done--is to determine the number of spaces available in each of the host area zones. After completing this, a network graph of the routes should be constructed, similar to that used in the bottleneck identification procedures. This procedure can be summarized simply as follows: Suppose that the risk area has been divided into m zones labeled $S_1, S_2, \ldots, S_m$ and that the number of people to be evacuated from these zones are $P_1, P_2, \ldots, P_m$, respectively. Then the risk area is represented graphically as m nodes, corresponding to the risk area zones, connected to a master source node (S) with arcs having "capacities" equal to the number of people to be evacuated, as illustrated below:



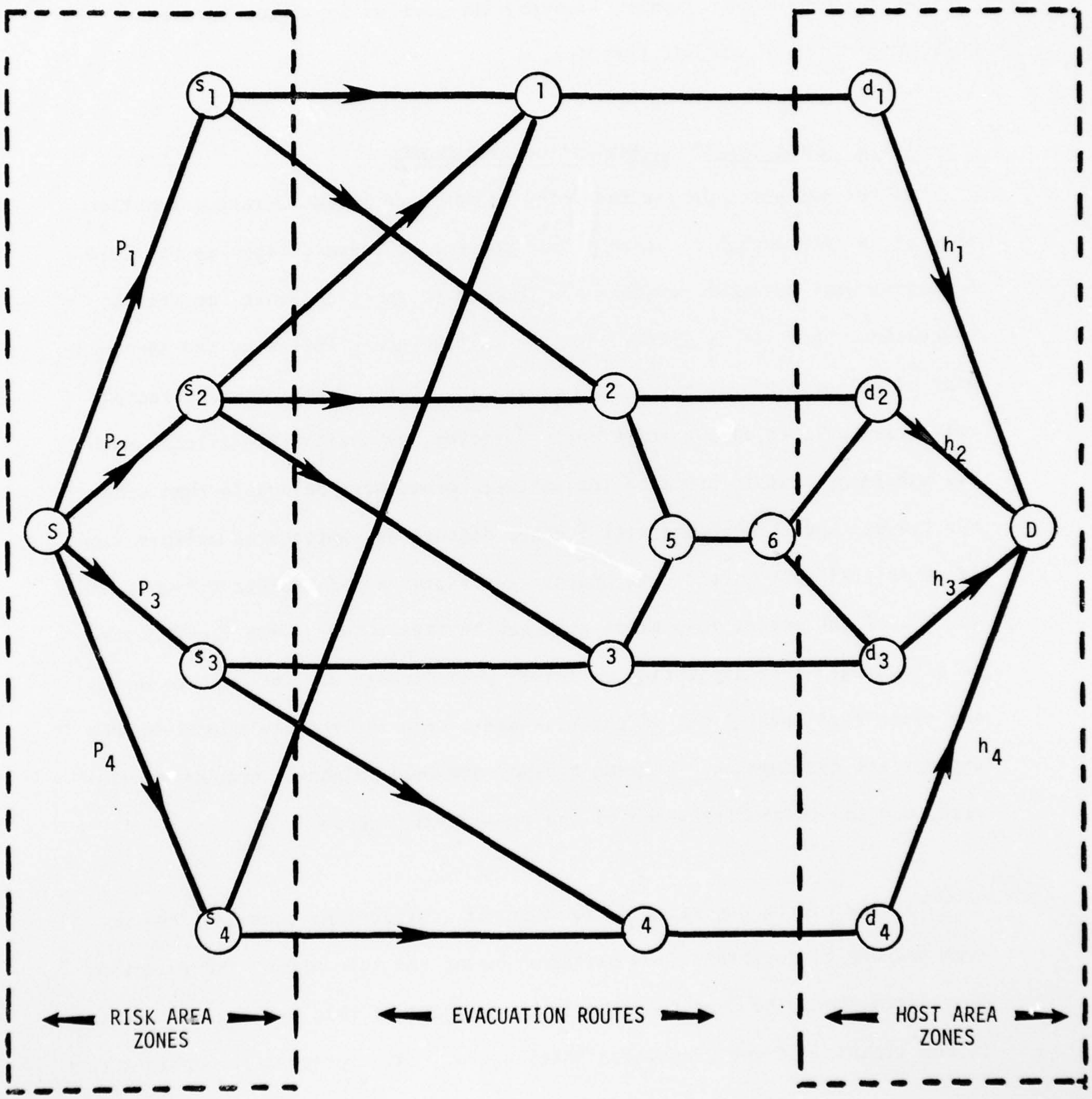
Similarly, all host area destination zones are represented by nodes d_1, d_2, $\ldots, d_n$ and are connected to a master destination node, D, with arcs having capacities h_1, $h_2, \ldots, h_n$ equal to the number of spaces available for evacuees in the corresponding host area zones. These host area nodes are then connected to the risk area nodes with a network of arcs representing the evacuation routes and labeled with the capacities of the evacuation routes in vehicles per hour multiplied by the average vehicle occupancy in persons per vehicle. An example of such a network is shown in Exhibit II-12.

The final step of this procedure is to determine the route assignment which maximizes the outbound flow. The problem may be stated succinctly as follows: The objective is to determine the steady-state pattern of flows through the network that maximizes the total flow from the source, S, to the host area D such that the rate of flow along each arc is less than or equal to the specified arc capacities and that flow is conserved at each node (i.e., flow into the node equals flow out of the node) other than the source and sink nodes S and D.

An efficient algorithm was developed by Fulkerson and Ford[B-10] for solving this problem, based on the max-flow min-cut theorem. The algorithm is presented in Appendix B of Volume I. Basically, the procedure is to repeatedly select any path from the source node S to the sink node D and assign the maximum flow to that path while satisfying the capacity and conservation of flow constraints. This process is repeated until none of the routes have "excess flow capacity." Excess flow capacity of a route equals the minimum remaining flow capacity of any section on the route.

EXHIBIT II-12

ROUTE ASSIGNMENT NETWORK GRAPH



For problems with a small number of nodes and arcs, this algorithm may be applied either graphically on a series of network diagrams or in matrix form using tables. Both methods are illustrated in Appendix B of Volume I. For large networks, however, the problem is solved more efficiently with an electronic computer.

B.2.4 Queue Length Investigation Procedures

If the perceived danger to a city is real enough to warrant evacuation then it is real enough to cause people to want to leave as soon as possible. No matter what movement controls are imposed to force a smooth, orderly evacuation, then, it is likely that the initial hours following the announcement of relocation will see a mass exodus in excess of any planning factors reflecting uniform flow assumptions. Moreover, even after the initial rush has subsided, certain hours of the day will prove more desirable than others for travel, and these hours will further distort assumptions of uniform flow. If an initial rush to the exit routes causes protracted traffic tie-ups, the success of the entire relocation plan may be threatened. Some families may be discouraged from attempting to leave, while others will attempt to use any clear road leading out of the risk area, even if it doesn't lead to an appropriate destination. Extreme tie-ups may lead to panic, abandoned vehicles, and the total disruption of the relocation process.

In view of the potential seriousness of traffic jams caused by the uneven peaking of departure flow patterns during the relocation, the following procedures should be used to quantify the effects of this peaking on traffic in the vicinity of the identified bottlenecks. This methodology combines the

logic of traffic engineering and queueing theory and is derived in detail in Appendix B of Volume I.

The first step is to estimate how many vehicles may be expected to arrive at the bottlenecks during each hour if all vehicles attempt to evacuate in:

(a) A single day;

(b) Two days; or

(c) Over a three-day period as scheduled.

For each of these conditions, two distributions of departure times should be considered:

(1) A uniform pattern in which vehicles leave the risk area uniformly over a 16-hour period each day (that is, the same number of people evacuate during each hour); and

(2) A peaked departure pattern following a normal distribution over a 16-hour period each day with the same mean and variance as the uniform distribution (that is, the majority of the evacuees attempt to depart during the middle hours of the 16-hour day).

Having computed the number of vehicles arriving each hour at the bottlenecks under these flow patterns, the planner should then estimate the queue lengths over time at the bottlenecks using the equations in Appendix B of Volume I. Then, based on the queue lengths and the evacuation flow rates over time, the maximum travel time to the bottlenecks and the total time to clear the traffic jam can be calculated.

These calculations will not only indicate the variation and degree of congestion conditions at the bottleneck, but will also indicate if it is possible to avoid this congestion by scheduling departures under various scheduling schemes.

B.2.5 Peak Leveling Measures

The debilitating effects of a bunched evacuation in which all residents rush for the exit routes at once have been addressed above. A number of measures may be adopted in an attempt to limit the number of vehicles on the highways at any given time. These measures are of two types: indirect measures designed to convince the population that a staggering of departure times is in their own best interests, and direct attempts to schedule departures on the basis of license plates or other identifying characteristics.

B.2.5.1 Indirect Persuasion. A number of procedures should be adopted in an attempt to influence evacuees to stagger their departure times. The chief argument behind all these procedures should be the repeated public announcement that if departure times are not staggered, evacuees will find themselves in the worst traffic jam they have ever experienced. Every available means should be adopted to bring this message home and to facilitate departure at off-hours. Several measures to accomplish the staggering of departure times are discussed below.

A. Broadcast Traffic Conditions Periodically: Periodic, if not continuous, information should be provided regarding traffic conditions leading to and on outbound routes. Reports of unimpeded traffic flow would be used to encourage those not on the road to get started. Temporary impediments, such as vehicle breakdowns, would be announced to assure relocating motorists that traffic stoppages would be temporary. Development of long queues of vehicles trying to get onto the outbound routes would cause the EOC to recommend that those not yet started delay for an hour or two.

B. Suggest Departures be Scheduled to Avoid Peak Hours: To the extent possible, those evacuees with scheduling flexibility should be encouraged to plan their departures for times when the load on the outbound road network is likely to be lowest. Late evening and early morning departures should be encouraged.

C. Keep Support Facilities Open Around the Clock: To facilitate the staggering of departures, gasoline stations and host area reception centers should be kept open on a 24-hour basis throughout the three-day evacuation period.

D. Advise Evacuees to Leave Second Autos in Risk Area: To the extent possible, families with more than one automobile available should be encouraged to depart in a single vehicle.

E. Introduce Odd/Even Purchase Limitations in Gasoline Stations: By restricting the sale of gasoline to vehicles with odd-numbered license plates on odd-numbered days and even-numbered plates on even-numbered days, planners achieve the dual effect of spreading departures and limiting gasoline station lines. Under crisis relocation conditions, odd-numbered license plates might be serviced on the first day of relocation, with even-numbered license plates serviced on the second day. No sales restrictions would be imposed on the third and last day of relocation.

B.2.5.2 Direct Scheduling of Departures. The departure times of certain groups of evacuees are within the control of evacuation planners. These groups include autoless residents and, to a certain extent, organizational relocatees. The departures of these groups should be scheduled to minimize congestion. In addition, attempts may be made to impose scheduled departure times on the large number of evacuees not affiliated with any organization. Several direct methods for scheduling the departure times of different groups of evacuees are discussed below:

A. Schedule Bus Departures to Avoid Peak Periods: Bus departures should be scheduled to straddle peak evacuation hours. This may be accomplished by using the early morning hours of each day to load those risk area residents requiring public transportation onto evacuation buses. Barring a serious breakdown, passengers should arrive at their reception center before breakfast. Buses making more than one trip per day to close-in reception centers could then perform double-duty by bringing critical workers into the risk area before taking on another load of evacuees. Although the scheduling of bus departures represents an effective means of controlling the evacuation times of a certain segment of the risk area population, this segment typically represents only 20% of that population.

B. Schedule Organizational Departures to Minimize Congestion: Previous risk area planning guidelines issued by DCPA[B8] contains the following suggestions regarding the relocation of organizations:

> ....It is better to schedule the relocation of organizations--governmental, institutional, and business--after the main movement of unattached families has occurred.
>
> Not all organizational households may be willing to wait for a scheduled departure time, but compliance can be improved markedly by emphasizing in organizational information releases and public announcements that failure to observe scheduled departures is likely to lead to involvement in traffic tie-ups.
>
> Institutional patients whose health would be affected adversely by inordinate movement delays should be scheduled near the end of the period.
>
> In general, essential employees of risk area organizations with uninterruptible functions should continue to report to their assigned shift while being instructed to make preparations to depart during their off-duty hours.

C. Scheduling the Departures of Unaffiliated Relocatees: The largest group of relocatees in any risk area will be those with automobiles who are unaffiliated with any controlling organization. This group will undoubtedly be motivated to move as quickly as possible, and poses the greatest potential threat to the free flow of relocation traffic. All of the indirect measures discussed above should be employed to encourage this group to spread their departures over the three-day period. In addition, in cases in which the exodus of unattached households is likely to require more than sixteen hours, an attempt might be made to enforce scheduled departures upon this group. One of the most promising programs for scheduling the departures of unattached households would be modeled after the odd/even license plate guidelines suggested for controlling the size of service station queues.

If this procedure is used, printed emergency instructions as well as broadcast guidance would suggest (or direct) that households with an auto having an odd-numbered license plate depart on the first day (for example), and those with even-numbered plates on the second day. No attempt would be made to enforce this rule, except possibly at service stations to expedite the preparations of the first group. Also, use of license plate numbers could cause many households to infer that the instructions might be enforced; hence, more would be led to follow them. In circumstances where the anticipated departure of the unattached

group is estimated to be about a day, the procedure could be applied to a morning/afternoon or first 12 hours/second 12 hours partitioning of the traffic load.[B8]

This procedure will reduce the likelihood of several traffic jams if the risk area is responsive. The possibility of such jams will not be entirely eliminated, however, as peaks occurring within each day's traffic patterns could still cause severe congestion.

Direct attempts to partition the population into hour-by-hour departure times should be avoided. Use of many partitions of the traffic load, such as assigning a time to each terminal number in an automobile license plate number, is not recommended, even though this would further smooth out departures. Asking those destined for particular host counties to delay leaving in preference to others is unlikely to be perceived as reasonable and fair (other than that which is automatic in deferring the movement of organizations, of which many will be destined to occupy the nearby hosting areas).[B8]

B.2.6 Traffic Control Measures

Control of the vehicle movements within the risk area may be necessary to assure smooth traffic flow in accessing and using outbound routes. Several options are available for controlling traffic movements. Controls may be active or passive, dynamic or static. Active controls might be exercised by having policemen direct each vehicle to a specific route and destination on the basis of driver interrogation or vehicle identification. An example of passive control would entail the barricading of a street to limit route choices. Dynamic controls are capable of adjusting to reflect hourly traffic conditions as monitored by helicoptor or observers at key intersections. Static controls are those which remain in place, unchanged, throughout the duration of the relocation period. The establishment of a contraflow lane for outbound traffic serves as an example of a static control.

As noted in DCPA's Risk Area Guide, the planning team should recognize that a movement control system in the form of traffic signs, traffic signals, and uniformed officers already exists in every risk area. The population is familiar with this system. To the greatest extent possible, this system should be left intact so as to minimize the special information or surprises required by or awaiting the traveler.

In most cities, adequate advance planning formulated in consultation with local traffic engineers and with due regard for normal travel patterns may help to minimize the amount of special movement control required under crisis relocation conditions. Where special controls are necessary, "....negative or passive controls, such as barricades, are to be preferred in order to reduce manpower requirements."[B8] Continuous broadcasting of traffic conditions and suggested routing alternatives can put the responsibility for exercising dynamic control in the hands of the individual driver.

B.2.6.1 Wrong-Way Flow. Most evacuation plans conducted in the 1950's suggested the possibility of converting all highways to one-way outbound movement. Use of the wrong side of a freeway or highway could conceivably double its capacity or, perhaps more important, double the number of ramps available in areas of concentrated population. However, discussions with Colorado highway officials and reviews of past evacuation studies have revealed several factors that appear to lessen the value of using the wrong side of a freeway.

In commenting on the difficulties of adapting the nation's freeway system to outbound flow, one recent report observes that:

> The initiation of wrong-way flow would be difficult and time-consuming. Sequential phasing would have to be developed so that upstream on-ramps were closed and traffic on the freeway directed off at certain off-ramps. This ramp closure and freeway clearing would involve physical control to guarantee success. The reliability of signs to perform the task is doubtful, since 100 percent clearing of the freeway would be required. One car proceeding in the direction opposite to the heavy flow could completely block the freeway by causing one major head-on collision.[12]

In a sense, establishing one-way flow on surface streets would be even more difficult than establishing one-way flow on freeways, since surface streets have far more access points that will have to be controlled. Even during the three-day relocation period, with intercity freight and critical worker movements, traffic flow requirements will not be exclusively one-way outbound.

In view of the difficulties and potential dangers associated with wrong-way flows and the desirability of maintaining two-way flows on intercity routes, wrong-way flows should be attempted only in instances where they are commonly employed to deal with peak commute problems, or as a last resort in areas in which the existing road network is clearly inadequate.

B.2.b.2 Dynamic Control of Outbound Flow. In cases where alternative routes and flow patterns can be identified, procedures should be developed for rerouting evacuation traffic around traffic jams and developing bottlenecks. Outbound flow should be monitored by helicopter, and timely reports on traffic conditions should be relayed to motorists. In the interests of conserving personnel, responsibility for complying with alternative routing suggestions should be left with individual motorists. However, alternative routing movements and contingency plans should be worked out in advance by planners and traffic engineers. In Colorado Springs, for example, evacuees

using southbound routes may be assigned to either Route 115 or I-25. In the event that one or the other of these routes becomes jammed, evacuees destined for points beyond Canon City may be advised to use the clearer route until traffic on the jammed route flows freely and the original evacuation routing patterns may be resumed.

B.2.6.3 Emergency Rescue Patrols. Plans should be made for handling stalled and disabled vehicles and for responding to accident reports in an expeditious manner during the three-day relocation period. Where two-way flow has been maintained, access by tow-trucks from "downsteam" maintenance facilities and gasoline stations will be relatively straightforward. Helicopter surveillance and regular police patrols over sections of the route will facilitate rapid response to accidents and stalls. As an added precautionary measure, vehicles regularly making the reverse run over the evacuation route (i.e., buses, vans, and carpools carrying critical workers) should be supplied with two-gallon cans of gasoline. These cans could be given to out-of-gas evacuees in outbound lanes and provide an additional measure of fuel insurance for commuting workers and others making regular trips upstream.

B.2.7 Truckstops and Terminals

The relative invulnerability of truckstops to nuclear attack, coupled with their importance in the day-to-day movement of intercity traffic, makes them a pivotal resource in any crisis relocation plan. The role of truckstops in crisis relocation planning has been discussed in detail in Reference B-11. In addition to their traditional role as fueling points,

truckstops would act as traffic control centers under crisis relocation conditions. In this role, they would act as:

(1) Checkpoints for rerouting or reassigning essential shipments;

(2) Interim consignment points for non-essential shipments;

(3) Relay points for drivers;

(4) Coordination and reassignment points for cabs and drivers; and

(5) Central assignment points for skilled mechanics.

Reference B-11 provides basic data on 2,682 U.S. truckstops, including name, address, telephone number, and brand of fuel sold. It also outlines the roles of risk-area and host-area truckstops under crisis relocation conditions. Using Reference B-11 as a guide, planners should work with truckstop operators to incorporate this general guidance in specific host- and risk-area plans.

B.2.7.1 Stress on Critical Host-Area Truckstops. In addition to providing fuel for an increased portion of intercity freight movements during the crisis relocation period, critical host-area truckstops will act as checkpoints for the rerouting or reassignment of essential shipments, interim consignment points for non-essential shipments, relay points for drivers, coordination and reassignment points for power units and trailers, and central assignment points for mechanics. Since truckstops pump an estimated 68% of the fuel used by intercity motor carriers, many drivers would ordinarily be stopping at these truckstops as part of their normal route plan, and the proposed emergency guidelines represent a relatively small deviation from "business as usual" for these drivers. Since a

significant portion of intercity truckers are destined for private terminals or for risk-area truckstops, however, guidance directing these truckers to host-area truckstops can be expected to put significant additional stress on the fuel tanks, parking space, and support facilities of these truckstops. The extent of this additional stress will vary from location to location, but certain average levels may be estimated.

If all intercity truck traffic were to be redirected to critical host-area truckstops, the potential business of an individual host-area truckstop might be expected to more than double. This can be illustrated by the following rough approximation of the potential relocation business for a host-area truckstop:

$$\text{Normal Business} \times \frac{\text{Total Number of Truckstops}}{\text{Host Area Truckstops}} \times \frac{\text{Total Intercity Fuel Sales}}{\text{Truckstop Fuel Sales}}$$

$$= \frac{\text{Normal Business}}{.71 \times .68}$$

$$= 2.07 \times (\text{Normal Business})$$

This estimate represents a nationwide approximation. The ratio of potential relocation business to normal business would be much higher in California and in the northeastern United States, where a higher percentage of truckstops are located within risk areas. Given the size of the potential increase in the business expected at critical host-area truckstops, then, certain measures must be taken to avoid swamping specific truckstops. A few such measures are discussed in the following paragraphs.

Truckstop Parking Requirements

As critical host-area truckstops become control centers for the inter-city shipment of essential goods, and as non-essential shipments and their vans accummulate in those centers, parking requirements may double and the parking space available at the typical truckstop may be expected to be inadequate to meet the demands placed upon it. A rough rule of thumb indicates that 18 units per acre may be parked comfortably at a truckstop, with each tractor-trailer combination having sufficient freedom of movement so that it can move out at any time without disturbing other units. The number of units per acre may be approximately doubled to 36 units per acre, if units are parked axle-to-axle and bumper-to-bumper with no maneuvering room. One option for making the most of the parking space at each truckstop is to park trailers with non-essential goods, closely spaced, on the less accessible portions of each truckstop's parking acreage. Another option would be to park trailers with non-essential goods off the truckstop premises. Each host-area plan will contain a listing of available open areas which might be used for parking space, along with an estimate of the space required to accommodate relocating automobiles (see Reference B-3). Trailers with densely-packed loads of non-essential goods might be parked close to the exposed walls of congregate-care facilities to provide an additional measure of expedient fallout protection for evacuees.

Truckstop Fuel Requirements

Although the parking requirements of a host-area truckstop may more than double, the curtailment of non-essential shipments during the crisis will limit the corresponding increase in fuel requirements. Estimates indi-

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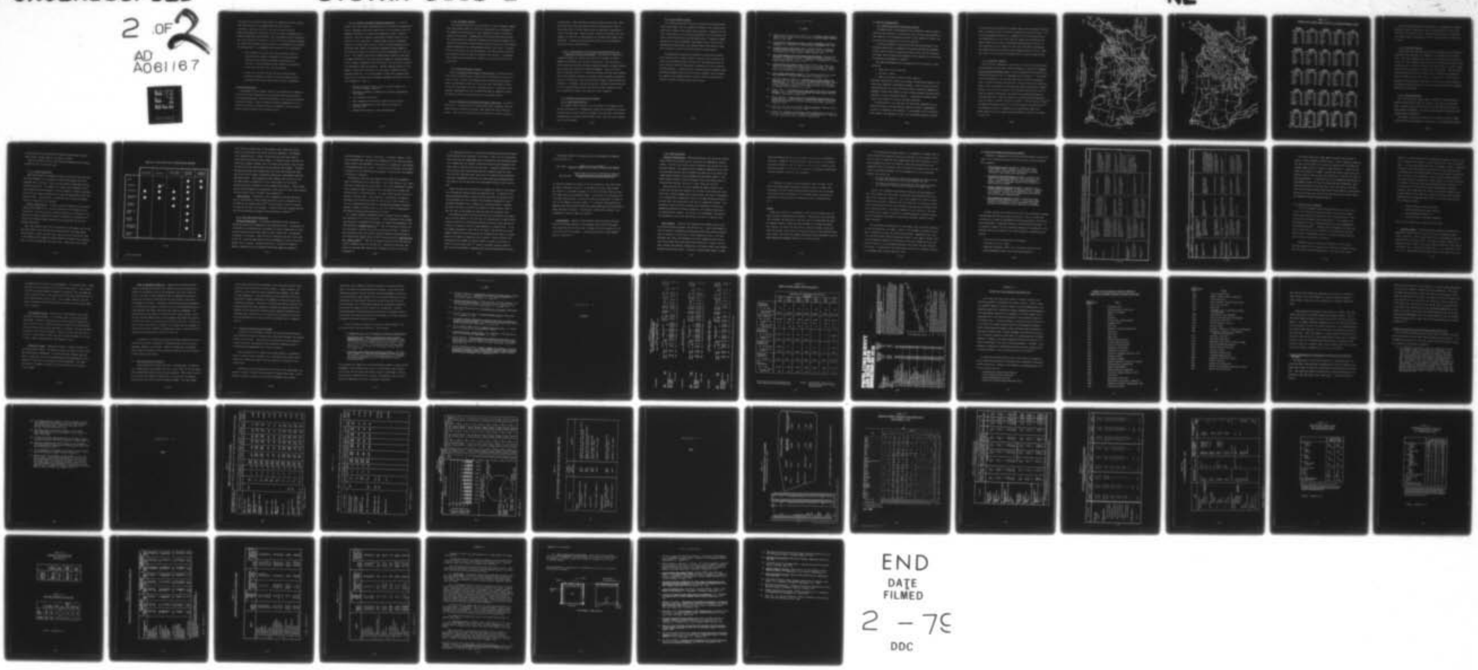

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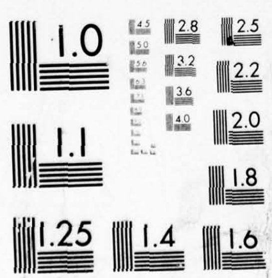

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

cate that 62% of intercity truck traffic is comprised of essential goods that would continue to be shipped during the crisis period. Accordingly, while the traffic at a typical host-area truckstop might be multiplied by a factor of 2.07 if all intercity shipments were passed through these control points, fuel requirements would be multiplied by a lesser factor of 1.28 (that is, .62 X 2.07) as non-essential shipments are sidetracked and power units and drivers are reassigned to the movement of essential goods. To accommodate this increase in fuel requirements:

1. Fuel allotments of critical host-area truckstops should be increased at the expense of shipments to risk-area gasoline stations and non-critical truckstops located within the risk area. This reallocation process should be incorporated in the state and local crisis relocation plans.

2. Trucks in the risk area at the time the relocation begins should be encouraged to refuel at risk-area terminals before proceeding to host-area control points to await reassignment.

Additional Requirements

Requirements for such support functions as maintenance and communications at host-area truckstops may be eased during the relocation period by reassigning personnel, particularly mechanics, from risk-area truckstops and service stations. Where on-premises sleeping accommodations and restaurant facilities are limited, truckers and emergency service personnel should be given priority over the general public.

B.2.7.2 Toward a Nationwide Emergency Organization. In the two decades since they became a prominent part of the intercity transportation picture, truckstops have proven themselves to be an invaluable source of emergency assistance to travelers and commercial truckers in natural disasters. They also represent a potentially valuable resource in the event of a crisis relocation. To make maximum use of this emergency resource, an attempt should be made to form a voluntary organization of truckstop owners capable of providing an emergency fueling capability for vehicles and havens of rescue for drivers and passengers in times of crisis. This organization would be formed without regard to brand name or company affiliation, since no single oil company or marketing combination of companies adequately covers the country, and since most truckstops are independently owned and operated. Minimum standards would be set for members to ensure that they would, in fact, play a significant role in emergency operations. An initial attempt to draft such standards might begin with the criteria used to designate secondary truckstops in the survey of Appendix B. That is,

1. Adequate parking (at least 25 units at urban locations and 50 units at highway locations);
2. Restaurant availability (adequate for location--approximately 30-50 seats);
3. Basic mechanical facilities;
4. Basic communications facilities (may lack wire services);
5. Sleeping accommodations (either directly available or adjacent); and
6. Adequate fuel storage (at least 20,000 gallons).

B.2.8 Intermodal Transfer

The greater flexibility of truck movement in time of emergency suggests that truck movement might be effectively substituted for rail movement in the immediate postattack period. Most commodities could be transferred between rail and truck. Recommendations for possible host-area locations for the construction of make-shift terminals can be obtained through interviews with railroad and trucking industry officials; plans for such terminals should be made part of the Transportation Annex of local plans. To ensure the most efficient use of fuel and manpower, such substitutions of service would usually be made on hauls of relatively short distance. Furthermore, the railroads should resume their customary role once rail service is reestablished.

B.2.9 Railroad Emergency Planning

B.2.9.1 Movement of Rail Panels to the Host Area. Railroads usually have flatcars preloaded with rail panels (on ties) spotted at various locations in order to repair track damage caused by washouts and derailments. Where such preloaded railcars are in the risk area, they should be moved to the host area during the crisis rleocation period. In addition, where possible, replacement rails not in panel form could be loaded on flatcars and moved to the host area during the crisis relocation period.

B.2.9.2 Movement of Critical Rolling Stock to Host Area. As noted in Section A.3.5, selected critical rolling stock (such as engines) should be moved from the risk areas to the host areas during the crisis relocation period. This critical rolling stock can be spotted at various locations in

the host areas. Most railroads have double-track every few miles; under conditions where fewer than normal trains are being operated, some of these double-track sections could be used for spotting or "pulling out" critical rolling stock. Where available, sidings are preferable for this purpose, as their use for spotting does not interfere with normal train operations. Locations of possible pullout points can be determined in interviews with railroad officials.

B.2.9.3 Identification of Key Host-Area Railroad Terminals and Preparation of Plans for Expansion. The problem of loading and unloading freight-cars could be very serious if terminals are badly damaged or destroyed in an attack on urban centers. Key host-area terminals should be identified and their expansion planned, including planning for the provision of materials-handling equipment. (Such a listing is shown in Appendix Table B.3.) Discussions between state and local planners and railroad industry personnel will provide data to planners on potential critical rolling stock siting locations and on terminal identification and expansion. In addition, such discussions will introduce railroad officials to civil defense thinking and provide them with some conception of what will be expected of them in the event of a crisis situation.

B.3 Probable Postattack Situation Summary

B.3.1 Road Network Survival

Key highway links have been cut in every major city targeted in postulated attack patterns. Although past studies have determined that detour routings could be found around every damaged link, one recent investigation estimated that such detours would increase travel times by factors ranging from 22 and 38 percent.

B.3.2 Rail Network Survival

If a nuclear attack were to occur, the nation's rail network would suffer heavy damage, with an estimated 41 percent of the classification yards and 53 percent of the repair shops surviving. It appears that the rail system could be 30 to 50 percent operational, but with reduced efficiency, within 30 days after the postulated attack. In general, damage and debris will cause considerable curtailment of rail service in the immediate postattack period, and a greater share of the nation's cargo will initially be carried by the more flexible trucking system.

In planning for postattack rail movement, key host-area terminals which could be used as control centers in time of crisis should be identified in the preattack period, and plans for the expansion and use of these terminals should be incorporated in appropriate crisis relocation planning documents. During the crisis relocation period, emergency power-generating equipment should be moved to these terminals, and rail panels for repairing track damage should be loaded on flatcars and spotted on sidings at various locations within the host area.

R E F E R E N C E S

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C. Fuel for Transportation

C.1. Overview of the Fuel Distribution System

As indicated above, these guidelines are presented in order to enable State and local officials to identify the likely location and magnitude of fuel supplies in the distribution pipeline, trace supplies in transit, and plan the future disposition of local fuel supplies.

A necessary component of any plan for fuel distribution under crisis relocation conditions is a compilation of detailed information regarding the fuel sources normally supplying the affected area, typical transportation modes, and the location and magnitude of fuel supplies in the distribution pipeline from producer to consumer.

The required information may be characterized as the answers to three questions:

1. Where does the fuel come from?
2. How does it come?
3. What is the present location of fuel supplies?

Questions involving fuel sources and national transportation capability are particularly important in postattack planning. Given the relatively short projected duration of a crisis relocation posture, questions regarding the immediate locations and identity of local fuel distributors are particularly important in crisis relocation planning. A comprehensive planning effort, however, must address all three of the above questions.

As indicated above, the "top down" and "bottom up" approaches are not mutually exclusive, and both should be applied to obtain a comprehensive picture of a community's fuel movement. In developing a crisis relocation plan, however, the importance of local fuel (petroleum) industry personnel

to the successful reallocation of supplies under crisis relocation conditions makes it imperative that the "bottom up" approach be used extensively. One of the most important features of a community's crisis relocation plan is the identification of those local industry leaders who are familiar with supply channels and who have a preliminary understanding of the ways in which operations must be modified to meet crisis relocation requirements. The identification and briefing of these industry leaders will be an important factor in the successful implementation of a crisis relocation plan.

C.1.1 "Top Down" Approach

One of the most comprehensive discussions of the total nationwide petroleum distribution system from a defense standpoint is provided in "Vulnerability of Total Petroleum System," a report prepared for the Defense Civil Preparedness Agency by the U.S. Department of the Interior.[C-1] This report provides information on the location and volume of crude oil production, crude oil pipeline network and capacities, refinery location and capacities. There is also an assessment of the petroleum system and postattack problems. Exhibits II-13 and II-14 (from the above-referenced publication) show U.S. crude oil pipeline distribution and capacities and product pipeline distribution capacities. Refinery capacity by state and pipeline mileage by state are shown in Appendix Tables C1-1 and C1-2. The U.S. Bureau of Mines[C-2] the American Petroleum Institute,[C-3] and the National Petroleum Council[C-4] are additional sources of information on a national and state level. Market shares of the ten largest gasoline marketers in the U.S. are shown in Table II-9.

Exhibit II-13

CRUDE OIL PIPELINE CAPACITIES

(THOUSANDS OF BARRELS DAILY)

as of December 31, 1972

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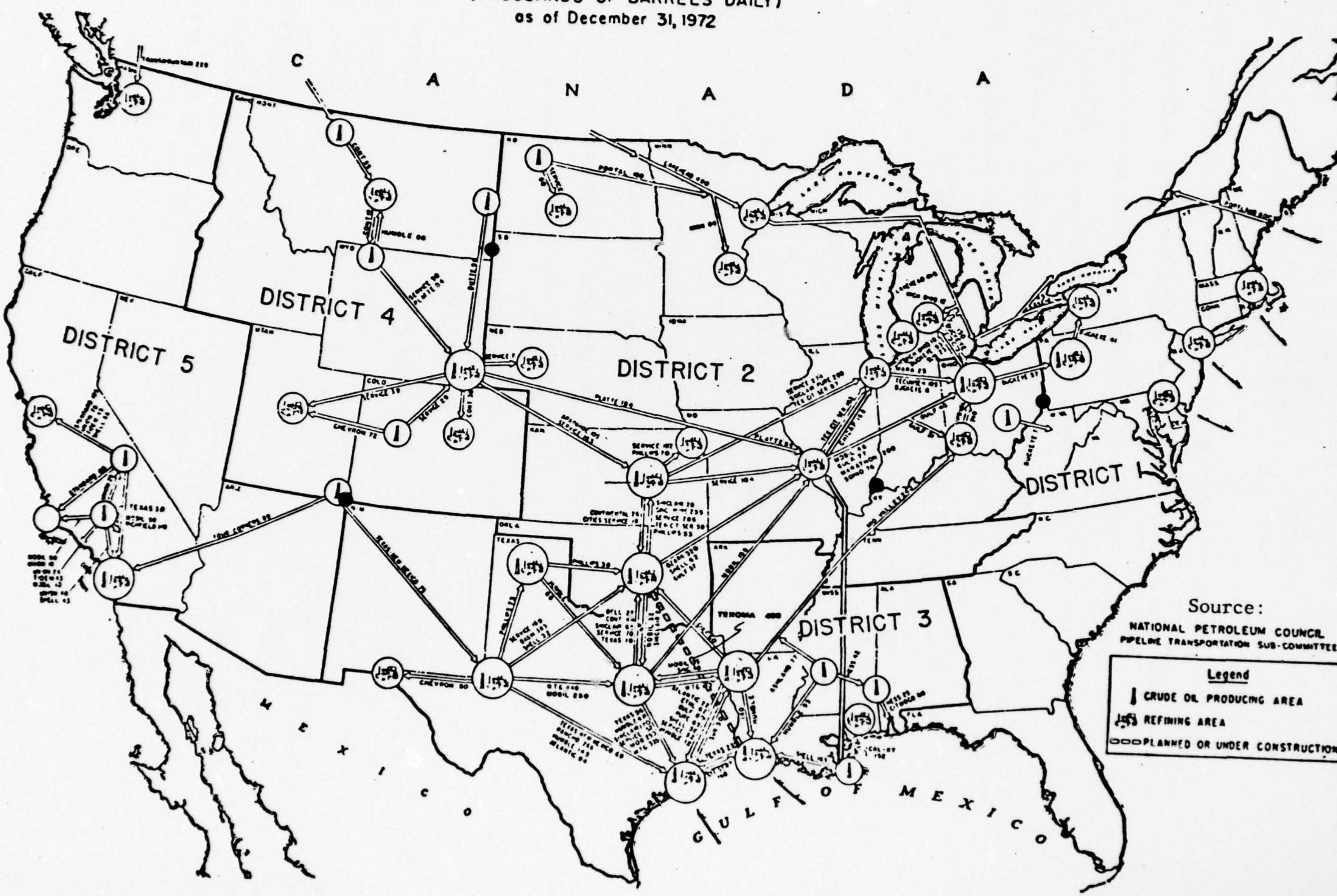
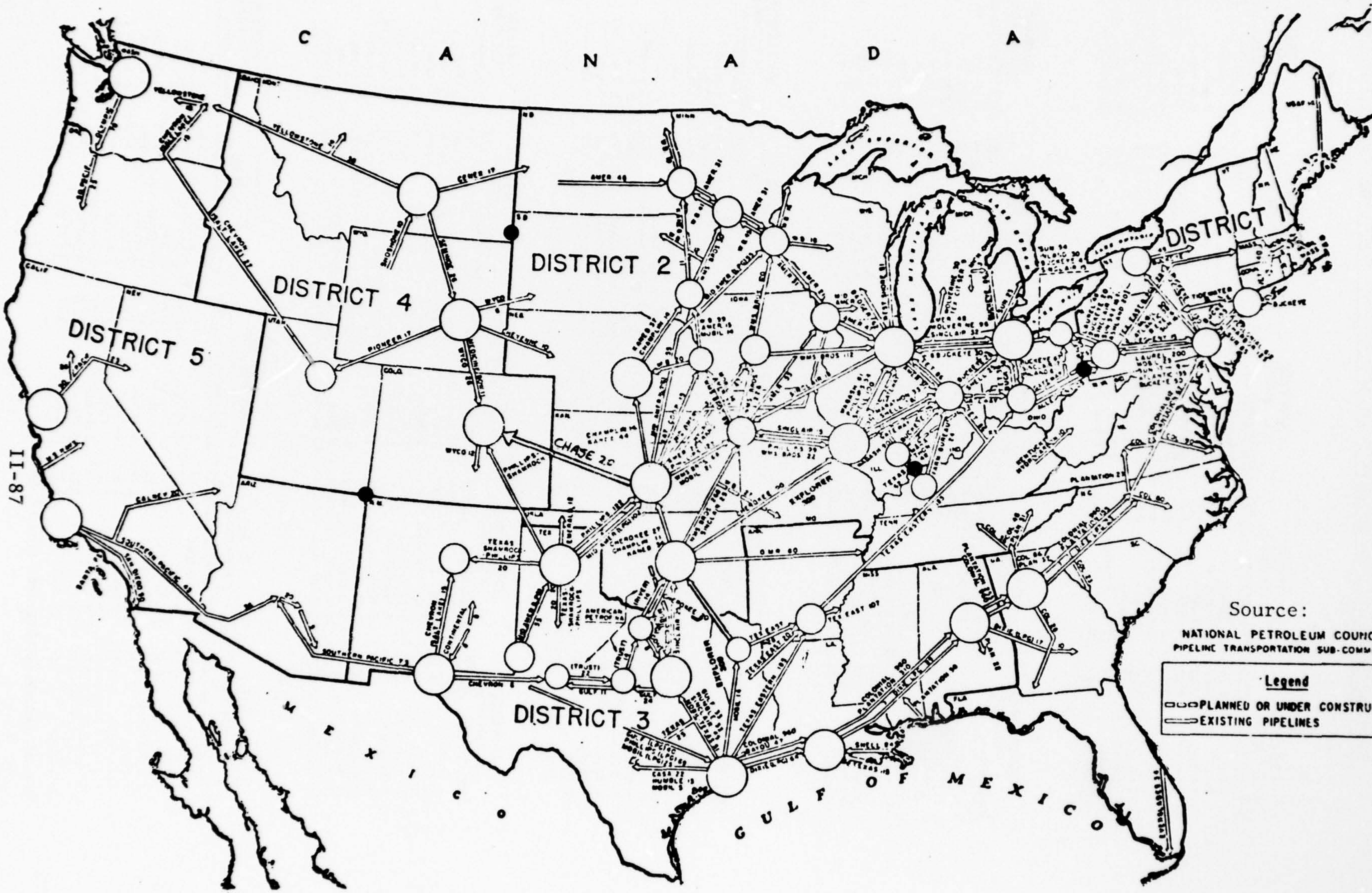


EXHIBIT II-14

PRODUCT PIPELINE CAPACITIES

(THOUSANDS OF BARRELS DAILY)
as of December 31, 1972

FA16622



Source:
NATIONAL PETROLEUM COUNCIL
PIPELINE TRANSPORTATION SUB-COMMITTEE

Legend
PLANNED OR UNDER CONSTRUCTION
EXISTING PIPELINES

TABLE II- 9

COMPANIES WITH LARGEST SHARE IN THE TOP 25 GASOLINE-CONSUMING STATES

CALIFORNIA (9,991,889,000 gal)

Rank, company	% Mkt.
1. Socal	16.38
2. Shell	14.01
3. ARCO	10.55
4. Union	9.07
5. Mobil	8.91
6. Texaco	8.62
7. Gulf	5.02
8. Phillips	5.02
9. Exxon	3.74
10. Douglas	3.34

TEXAS (6,355,842,000 gal)

Rank, company	% Mkt.
1. Texaco	14.43
2. Exxon	14.27
3. Gulf	9.43
4. Mobil	7.44
5. Shamrock	6.05
6. Petrofina	4.67
7. Shell	3.66
8. Phillips	3.64
9. Continental	3.41
10. Sun	3.18

NEW YORK (5,801,769,000 gal)

Rank, company	% Mkt.
1. Mobil	18.65
2. Texaco	11.11
3. Shell	8.98
4. Exxon	8.44
5. Gulf	6.89
6. Sun	6.57
7. American	5.17
8. ARCO	4.10
9. Getty	3.38
10. Cities	1.89

ILLINOIS (5,186,726,000 gal)

Rank, company	% Mkt.
1. American	19.32
2. Shell	9.92
3. Texaco	6.70
4. Clark	6.04
5. Mobil	5.53
6. ARCO	5.52
7. Phillips	4.11
8. Sun	3.58
9. Marathon	3.28
10. Gulf	3.26

OHIO (4,931,772,000 gal)

Rank, company	% Mkt.
1. Sohio	24.70
2. Marathon	8.98
3. Sun	7.80
4. Ashland	7.57
5. Shell	7.42
6. Gulf	6.02
7. Texaco	4.25
8. Union	3.93
9. ARCO	3.76
10. Clark	3.21

PENNSYLVANIA (4,714,826,000 gal)

Rank, company	% Mkt.
1. ARCO	15.82
2. Exxon	10.65
3. Sun	10.19
4. Gulf	8.19
5. Texaco	7.94
6. Mobil	7.61
7. American	5.98
8. Phillips	2.06
9. BP Oil	1.30
10. Getty	1.28

MICHIGAN (4,423,083,000 gal)

Rank, company	% Mkt.
1. American	14.22
2. Shell	9.74
3. Mobil	8.65
4. Gulf	7.02
5. Sun	5.98
6. Marathon	5.93
7. Texaco	5.50
8. Leonard	3.17
9. Union	2.76
10. ARCO	2.62

FLORIDA (3,883,909,000 gal)

Rank, company	% Mkt.
1. Socal	11.90
2. Gulf	9.20
3. Shell	8.19
4. Phillips	7.75
5. American	7.28
6. Texaco	7.21
7. Marathon	5.21
8. Exxon	5.11
9. Tenneco	4.52
10. Union	4.41

NEW JERSEY (3,237,864,000 gal)

Rank, company	% Mkt.
1. Exxon	16.69
2. Hess	9.32
3. Sun	9.20
4. Gulf	7.15
5. Mobil	6.92
6. Shell	6.90
7. American	5.47
8. Texaco	4.77
9. Cities	4.76
10. Getty	4.07

GEORGIA (2,871,957,000 gal)

Rank, company	% Mkt.
1. Socal	13.08
2. Gulf	11.80
3. Texaco	7.08
4. American	7.04
5. Shell	5.95
6. Union	5.45
7. Tenneco	5.29
8. BP Oil	5.19
9. Exxon	4.98
10. Phillips	3.60

INDIANA (2,682,475,000 gal)

Rank, company	% Mkt.
1. American	13.82
2. Marathon	11.02
3. Rock Island	8.79
4. Shell	8.73
5. Sun	6.51
6. Clark	5.50
7. Ashland	5.08
8. Texaco	4.98
9. Phillips	4.70
10. Gulf	4.29

NORTH CAROLINA (2,619,936,000 gal)

Rank, company	% Mkt.
1. Exxon	14.14
2. Gulf	8.05
3. Texaco	7.90
4. Shell	6.55
5. American	6.53
6. Phillips	5.49
7. Union	4.74
8. Service Dist.	2.35
9. Cities	2.26
10. Sun	2.04

MISSOURI (2,562,805,000 gal)

Rank, company	% Mkt.
1. American	15.05
2. Phillips	8.68
3. Shell	5.35
4. ARCO	5.34
5. Mobil	4.64
6. Texaco	4.17
7. Skelly	4.01
8. Sun	3.95
9. Gulf	3.56
10. MFA	2.88

VIRGINIA (2,354,216,000 gal)

Rank, company	% Mkt.
1. Exxon	17.15
2. Texaco	11.66
3. Gulf	8.66
4. Shell	7.37
5. Cities	6.54
6. American	6.42
7. Sun	3.97
8. Union	3.94
9. Continental	3.52
10. ARCO	3.45

MASSACHUSETTS (2,276,122,000 gal)

Rank, company	% Mkt.
1. Mobil	14.13
2. BP Oil	10.11
3. Texaco	9.57
4. Shell	8.98
5. Gulf	7.32
6. Exxon	7.24
7. Sun	6.02
8. Cities	5.49
9. ARCO	5.26
10. Northeast	5.02

TENNESSEE (2,154,456,000 gal)

Rank, company	% Mkt.
1. Exxon	13.36
2. Gulf	9.51
3. Cities	8.33
4. American	7.66
5. Texaco	7.53
6. Shell	7.40
7. Continental	4.81
8. Tenneco	4.69
9. Monsanto	4.07
10. Triangle	3.87

MINNESOTA (2,130,646,000 gal)

Rank, company	% Mkt.
1. American	16.51
2. Mobil	8.41
3. North Western	8.12
4. Phillips	6.41
5. Continental	5.09
6. Gulf	4.97
7. Union	4.12
8. Skelly	4.10
9. Texaco	4.04
10. Shell	3.38

WISCONSIN (2,115,547,000 gal)

Rank, company	% Mkt.
1. American	14.24
2. Mobil	8.43
3. Texaco	5.49
4. Murphy	5.40
5. Cities	4.65
6. ARCO	3.90
7. Phillips	3.23
8. Union	3.09
9. Shell	3.05
10. Farmers Union	2.94

MARYLAND (1,778,458,000 gal)

Rank, company	% Mkt.
1. Exxon	17.42
2. American	10.28
3. Shell	9.12
4. Texaco	8.17
5. Gulf	7.56
6. BP Oil	7.48
7. Sun	5.88
8. Crown Central	4.03
9. Ashland	3.91
10. Cities	3.81

ALABAMA (1,777,295,000 gal)

Rank, company	% Mkt.
1. Socal	13.44
2. Gulf	8.69
3. Shell	7.51
4. Texaco	6.79
5. Triangle	6.01
6. American	5.80
7. Exxon	5.17
8. Union	4.80
9. Cities	3.99
10. Murphy	3.51

LOUISIANA (1,771,955,000 gal)

Rank, company	% Mkt.
1. Exxon	19.73
2. Texaco	10.75
3. Gulf	10.67
4. Continental	8.17
5. Shell	7.51
6. Tenneco	6.10
7. Atlas	5.34
8. Murphy	3.73
9. Mobil	3.01
10. Phillips	2.71

IOWA (1,676,145,000 gal)

Rank, company	% Mkt.
1. American	16.72
2. Sun	8.38
3. Phillips	5.74
4. Texaco	3.67
5. Skelly	3.61
6. Derby	3.56
7. Continental	3.53
8. Mobil	3.46
9. Gulf	3.24
10. ARCO	2.73

WASHINGTON (1,644,760,000 gal)

Rank, company	% Mkt.
1. Socal	14.72
2. ARCO	12.36
3. Texaco	11.59
4. Shell	10.96
5. Union	8.34
6. Mobil	6.89
7. Phillips	6.03
8. Exxon	5.98
9. Time	3.72
10. Gulf	3.57

KENTUCKY (1,592,334,000 gal)

Rank, company	% Mkt.
1. Socal	16.62
2. Ashland	14.29
3. Gulf	9.90
4. Texaco	7.48
5. Shell	7.04
6. Sun	5.52
7. Exxon	4.21
8. Marathon	3.67
9. ARCO	3.06
10. Phillips	1.83

MISSISSIPPI (1,551,440,000 gal)

Rank, company	% Mkt.
1. Socal	12.57
2. Cities	9.54
3. Gulf	7.96
4. Texaco	6.95
5. Union	6.36
6. Exxon	6.04
7. American	5.57
8. Shell	5.42
9. Signal	5.25
10. Sun	4.26

Source: Oil and Gas Journal – May 14, 1973

Each five years, the Bureau of the Census, U.S. Department of Commerce, publishes a Census of Retail Sales which includes gasoline station sales in the U.S. by state and county. The Bureau of the Census also publishes, in a similar report, gallonage data on fuel storage capacity by state and by county.

C.1.2 "Bottom Up" Approach

A major source of supply and distribution information on the "bottom up" approach are the individual oil companies in the respective risk and host areas. Most major companies have offices in large and medium-sized cities in the U.S. These companies usually have data on market share, location and storage capacity of stations, location and storage capacity of bulk storage facilities, local refineries, pipelines and flow patterns. The State Petroleum Association may also be a useful source of information on petroleum sales by supplier at the state, county, and city level. Interviews with personnel of the regional or local offices of FEA are also most helpful in providing an overview of the fuel sources and market shares of all producers serving a particular area.

C.1.3 Planning Guidelines

The crisis relocation planner should identify the production and consumption of each type of fuel on a statewide, host area, and risk area basis. Refinery output and net inflow or outflow from the host and risk areas should be determined. The location and capacities of pipeline bulk storage should be determined.

The location, capacities and ownership of pipelines and bulk storage facilities should be determined. In addition, a list of gasoline stations

in the host and risk areas should be prepared including name, address, brand carried, storage capacity, and number of pumps.

Table II-10 shows the type of fuel-related information which should be obtained for the risk and host areas.

C.2.1. Normal Requirements

When total normal fuel consumption figures for the host and risk areas have been obtained, it is necessary to divide these figures into their component parts to provide a basis for assessing fuel requirements during and after relocation. The components of normal fuel consumption are personal movement and goods movement. Personal movement is further subdivided into work trips, family business trips, social and recreational trips, and education trips. Goods movement is subdivided into two major categories: intercity trucking and local trucking.

Personal Transportation. The make-up of each component of the personal transportation budget and its relative importance in that budget are discussed below. The classification scheme and statistics are reported in the nationwide Personal Transportation Survey[C-5] conducted by the Bureau of the Census for the Federal Highway Administration during 1969 and 1970 (see Appendix Table C2-1).

Work trips comprise nearly 42% of the personal travel budget, and include both the journey to and from work and related business trips made during the working day. Family business trips comprise 19.4% of the vehicle miles in the personal travel budget and include medical and dental trips, shopping trips, and other related family business trips. Educational trips account

TABLE II-10 FUEL SUPPLY AND DISTRIBUTION DATA REQUIRED

	REFINERIES	PIPELINES	BULK STORAGE FACILITIES	GASOLINE STATIONS	PETROLEUM COMPANIES
NAME				●	●
ADDRESS		● [1]		●	●
OWNERSHIP	●	●	●	●	
THROUGHPUT CAPACITY	●	●	●	●	
STORAGE CAPACITY			●	●	
NUMBER OF PUMPS				●	
BRANDS CARRIED				●	
THROUGHPUT BY PRODUCT				●	
SHARE OF MARKET					●

[1] Map of Network

for 4.7% of the vehicle-miles in the personal travel budget and include trips to and from school and church, and trips undertaken in discharging civic responsibilities. Social, recreational and other trips comprise nearly 34% of the personal travel budget. The largest single classification within this category includes visits to friends and relatives, which account for 12% of the total vehicle-miles in the personal travel budget. Vacations and pleasure outings are included within the social and recreational heading, as are trips to parks, recreational facilities, entertainment functions, and sports events. These figures may vary slightly from city-to-city, and the best sources of information on local travel habits are the origin-destination surveys conducted by local transportation agencies. Should recent surveys from such agencies be unavailable, older surveys or more recent national statistics may be used to estimate travel propensities.

Goods Movement. Information on the consumption of gasoline and diesel fuel in the movement of goods between and within cities is provided by the DOT publication, Highway Statistics[C-6] and the Volume I, Section 2 analysis of intercity and local truck movement. Intercity and local trucking accounts for 28% of the gasoline consumed in the United States annually.[C-6]

C.2.2 Fuel Needs During Relocation

Personal Transportation. The primary requirement for fuel during the relocation period will be generated by the evacuation itself. For purposes of illustration, in estimating fuel requirements it may be assumed that all families with access to autos would travel in their "first" auto. As indicated in Exhibit 2.3 of Volume I, about 80% of U.S. households own one or more cars. In the U.S., there are more than 100 million automobiles to serve 214 million people; thus, in theory, everyone could leave a risk area by automobile. However, automobiles are not uniformly distributed among all segments of

society and among all cities or risk areas. In general, however, it has been determined that risk areas with a population of less than one million people exhibit some uniformity in availability of automobiles, with 85%-95% of households having one or more. A more detailed discussion of the number of persons in a risk area who may be assumed to leave by first auto appears in Section A.2 (Vehicles).

The balance of the risk area population not using first automobiles would be evacuated by bus or other means. Local buses (public, city, school, tour) may be sufficient for this purpose. This may be determined by comparing the remaining number of persons to be evacuated with the number and seating capacity of available buses. Of course, more than one trip may be planned to the host area. If bus capacity is insufficient, bringing in additional buses from outside the risk area or use of taxis, trucks, or rail may be examined as other means of supplementing passenger evacuation capacity. However, trucks and rail are not well-suited to moving people and should be used only when absolutely necessary.

For current estimates, automobiles may be assumed to have an average fuel efficiency of 12.5 miles per gallon. Annual variations in the average fuel efficiency of automobiles and trucks are computed and published in the FHWA publication, Highway Statistics.[C-6] The fuel efficiency of buses will vary according to type and size of buses making up the fleet. Studies of fuel efficiency and use for various transport modes have been analyzed by the Transportation Systems Center of DOT in the publication, Technology Sharing - Energy Primer.[C-7] Some of the relevant results of this work are described in Appendix Table C2-3 through C2-8. Statistics on the fuel efficiency of buses and other vehicles may be found in Tables C2-9 and C2-10 of Appendix C.

By combining statistics on vehicle fuel efficiency with the total person-miles traveled in the relocation (see Volume I, Table 2.6 for illustration), daily and total fuel requirements may be estimated for the evacuation period. It is assumed that all vehicles leaving the risk area would originally fill their tanks at stations within the risk area. Automobiles destined for distant locations would require additional fuel somewhere along the route. Given the fact that much normal travel will be curtailed during relocation, total fuel requirements within the risk area during the relocation period are likely to be less than total fuel requirements during a normal working day.

Within the host area, evacuation fuel demands are likely to fall heavily upon the gasoline stations along the evacuation route. In addition to refueling evacuating vehicles, these stations would also be expected to meet the requirements of local residents, the estimated consumption of local residents and added to the consumption by evacuating vehicles. Measures may have to be taken to bolster fuel supplies at those stations likely to bear the brunt of the demand for refueling along the evacuation route.

Fuel demands during the relocation period will be imposed by the commuting of critical workers to the risk area, the continuation of normal business within the host area, certain family business and social trips, and the continuation of intercity and local cargo movement on a reduced scale. It can be assumed conservatively that 20% of the workers from the risk area would commute during the relocation period; this estimate may be taken as an upper bound on the number of commuting critical workers. Recent estimates have indicated that the number of critical workers is likely to be closer to 7%-8% of the total work force.[C-8] However, estimates should be made for each risk area individually, depending upon the prevailing conditions there.

The general formula for computing the fuel requirements of commuting critical workers is:

$$\text{Fuel Needs} = \frac{\text{Number of Critical Workers}}{\text{Effective Commute Vehicle Capacity (Workers Per Vehicle)}}$$

$$\text{Multiplied By: } \frac{\text{Average Round Trip Distance Between Risk Area and Host Counties Housing Critical Workers (Miles)}}{\text{Commute Vehicle Fuel Efficiency (M.P.G.)}}$$

In using this formula, of course, it will be necessary to take into account the type of vehicles to be used. If automobiles are used, three persons per vehicle is a reasonable estimate; if, on the other hand, buses are used, this figure would be considerably higher. (See Section A for the capacities of various types of buses.) The use of buses could bring about a savings of fuel in the commute of critical workers. It is possible that gasoline consumed for work trips within the host area would remain about the same before, during and after relocation. In making fuel calculations, however, local circumstances should be taken into account.

Goods Movement. Intercity cargo movement during relocation will generally follow normal patterns, with movements restricted critical goods. Local cargo flow will be restricted to movement of critical goods, but travel distance will be increased. A detailed discussion of cargo movement appears in Section A.3.

C.2.3 After Relocation

Personal Transportation. Following relocation, personal travel requirements within the risk area would be limited to the commuting of critical workers. Fuel for this activity would be obtained from selected risk area gasoline stations. The amount of fuel consumed by commuting critical workers following relocation may be assumed to be identical to the amount consumed during relocation, since presumably the work would continue. This amount would be equal to the fuel required to move the critical share of the work force from host facilities to jobs within the risk area.

Within the host area, it can be assumed that family business trips by both risk and host area families will continue at pre-evacuation levels. These trips include shopping trips, medical trips, and trips to restaurants. It is assumed that no educational trips will be made following relocation, and that social and recreational trips will be considerably reduced. Post-evacuation trips by risk area residents may be reduced or eliminated by impounding automobiles following relocation; such a measure would result in significant fuel savings. The action to be recommended will depend on the availability of fuel and other factors relevant to a specific area.

Goods Movement. Intercity truck movements are assumed to drop to 60% of the pre-evacuation movement (see Section II-A). Local truck movement in the risk area will undoubtedly drop during and after the relocation period. Using an analysis of truck trips in eleven composite cities, it has been estimated that local truck movement of critical commodities and services will be only about 50% of that under normal conditions. However, the distance traveled with probably increase due to the need to move trucks greater distances into the host areas. Of course, the percentage changes in commo-

dities carried and the increase in distance traveled will be different in each case. Volumes of local and intercity cargo movement within the host area may be reduced by factors identical to those used in adjusting risk area cargo volumes. In the host area, however, no adjustment need be made for the increased distance of local movements.

In computing the amount of fuel consumed by family business, social trips, and cargo movement during the relocation period, the daily fuel requirements for these trips before and after relocation may be averaged. (Illustrative fuel requirements for the Colorado Springs risk and host areas before, during and after relocation are shown in Appendix Table C2-2.)

Summary

Under any foreseeable circumstances, total fuel requirements will probably decrease during and after relocation. The decrease in the risk area will be marked, and conditions in the host area will depend upon the specific measures taken to control the fuel consumption following relocation. Fuel supplies will need to be bolstered at selected locations in the host area, particularly those locations serving as refueling stops along the evacuation route. The chief fuel problem anticipated during relocation is one of redistributing the supplies from the risk to the host area.

In evaluating the available options, it is important to remember that so long as normal fuel production rates are maintained, the total supply of motor fuel is likely to exceed the total demand during and after relocation. Unless fuel shortages exist prior to relocation, then, there should be more than enough motor fuel to go around. Since the nature of the product does not lend itself to individual hoarding, the chief arguments for strict conservation measures and controls are:

1. To ensure that gasoline and diesel fuel supplies are shifted to meet the needs and priorities of the relocated population; and
2. To reduce the vulnerability of the nation's fuel supplies by building stockpiles in host-area bulk terminals and storage tanks.

Exhibit II-15 summarizes the principal advantages and disadvantages of the various options for controlling, distributing, and conserving motor fuel under crisis relocation conditions. Since total supplies are likely to exceed demand during and after relocation, and since motor fuel is difficult to hoard, strict rationing controls are not necessary for ensuring fuel availability during a relocation period. The primary argument for such controls is that they will create excess supplies which can be stockpiled against a potential attack and will help prepare the public for postattack rationing, should an attack follow relocation.

The chief motor fuel problem to be faced under crisis relocation conditions is one of distribution, not supply. Stocks in the secondary distribution system must be redirected so they are available where needed. Depending on the situation, this may be done either by using tank trucks to take supplies directly from risk-area pipeline terminals and refineries to host-area storage facilities and gasoline stations, or by intercepting pipeline flows before risk-area terminals are reached. To facilititate the redistribution process, any regulatory barriers to intercompany fuel transfer should be lifted.

C.3 Motor Fuel Control and Distribution Options

Alternative stragegies for controlling the distribution of motor fuel under crisis relocation conditions may be classified into the following four categories:

1. Fuel Rationing Systems designed to control fuel sales at the retail level. Examples of such systems include coupon controls, odd/even sales restrictions, purchase limitations, and minimum tank requirements.

2. Distribution System Adjustments designed to redirect fuel supplies to host area storage facilities and gasoline stations. Such adjustments may leave normal distribution channels intact or interrupt the flow of fuel before risk area outlets are reached.

3. Product Integration Measures designed to speed the distribution process and simplify adjustment procedures. Examples of such measures include the encouragement of intercompany fuel transfers, elimination of product separation, and the unrestricted use of leaded gasoline.

4. Fuel Conservation Measures designed to reduce fuel needs during the crisis relocation period. Such measures might include the impounding of private automobiles following relocation and increased reliance upon buses and carpools.

The above options are not mutually exclusive, and a successful strategy for providing fuel during and after relocation is likely to require the interaction of a number of complementary rationing procedures, distribution system adjustments, integration techniques, and conservation measures. In an attempt to identify the most promising combination of alternatives, each potential option was evaluated in the light of general considerations concerning:

° Pre-crisis set-up and maintenance requirements;

° Potential post-crisis legacy;

° Operating requirements under crisis relocation conditions; and

° System performance under crisis relocation conditions.

EXHIBIT II-15 SUMMARY OF MOTOR FUEL CONTROL AND DISTRIBUTION OPTIONS

ALTERNATIVE	CONCEPT	PRINCIPAL ADVANTAGES	PRINCIPAL DISADVANTAGES	SUMMARY
FUEL RATIONING	Control fuel sales at retail level through a variety of strategies:			
• Coupons	• Ration coupons must be presented when purchasing gasoline.	Permits selective control & conservation of fuel supply; coupons serve as sales record & may substitute for payment in case of critical workers.	Administrative headaches	Strict rationing may be necessary if autos are impounded; Such controls will probably be needed following an attack, however.
• Odd/Even	• Sales to cars with odd (even) license plates are permitted only on odd-(even-)numbered days; unrestricted purchases permitted in risk area on third day of evacuation.	Smooths peak evacuation flow & limits gas lines.	Might be perceived as inequitable; could limit draining of risk area gas inventories over three-day period.	Possibly useful as a means of spreading departure times, if carefully coordinated with other scheduling techniques
• Purchase Limits	• No single purchase shall exceed a pre-specified amount (for instance, 10 gallons)	Permits more equitable distribution under shortage conditions.	Prevents draining of risk area inventories	Possibly useful in host area; should not be applied in risk area.
• Minimum Sales Levels	• Purchases permitted only if gas in tank is below a pre-specified level (i.e., half full).	Shortens lines by preventing "topping-off"; limits inventory in gasoline tanks.	Potentially frustrating if limit is low; ineffectual if limit is set high.	Of limited importance; if used, different limits should be established in host & risk areas (i.e., half tank in host area, 3/4 tank in risk area).
DISTRIBUTION SYSTEM ADJUSTMENTS	Redirect fuel supplies to host area bulk storage facilities & gasoline stations			Redirection of supplies in secondary distribution must be accomplished. The exact means will depend on state, regional & local circumstances.
• Redirect Flow From Risk to Host Area Terminals & Stations	• Take supplies directly from pipeline terminals & refineries to all host area facilities & gas stations.	Gets fuel where needed with minimum disruption of existing network; minimizes vulnerability of secondary inventories.	Increased risk area exposure for distributors.	
• Bypass Risk Area Terminals	• Intercept pipeline flows before risk area terminals are reached.	Minimizes risk area exposure of distributors; could improve distribution efficiency.	Disrupts normal flow patterns.	

(EXHIBIT II-15, CONTINUED)

ALTERNATIVE	CONCEPT	PRINCIPAL ADVANTAGES	PRINCIPAL DISADVANTAGES	SUMMARY
PRODUCT INTEGRATION	Speed distribution & simplify redirection procedures by permitting comingling of product:			
• Permit Inter-company Transfers	° Drop brand distinctions & allow retail stations to accept deliveries from any producer.	Increases flexibility in developing reallocation schemes.	Potential abuse; possible regulatory limitations; additional administrative headaches.	Should be encouraged where consistent with state-level redistribution plans. Any regulatory bars to this practice should be lifted, but most firms prefer to maintain integrity of their systems and this should not greatly inhibit flow.
• Eliminate Product Distinctions	° Drop product separation & permit intermingling of regular, unleaded & premium products.	Simplifies and speeds distribution somewhat.	Reduced engine performance.	Probably unnecessary; permit only if distribution system bottlenecks develop.
• Eliminate Restrictions on Use of Leaded Gasoline	° Allow leaded gas to be used in all autos.	Ensures that late-model cars will be able to refuel along evacuation route.	If permitted over extended period, damage to catalytic will result.	Permit during three-day relocation period.
CONSERVATION MEASURES	Introduce various fuel conservation measures:			
• Limit Use of Relocated Vehicles	° Impound risk area autos once host area is reached or institute temporary pass system.	Significant fuel conservation potential; simplifies security procedures.	Perceived infringement of personal liberties.	Has been recommended for public safety purposes & should also result in significant fuel savings.
• Use Buses Whenever Possible	° Use buses extensively in critical worker commute & host area transportation.	Fuel conservation.	Worker commute will require additional organization and scheduling.	Use buses whenever possible, both in commuting critical workers & in providing host area transportation.

The relative motor fuel supply-demand situation outlined above is typical of that throughout the United States. Other researchers examining the need for fuel under crisis relocation conditions have concluded that an ample supply exists in available storage facilities. Studies of risk areas in one region, for example, indicate that service station and local pipeline stocks of fuel are more than sufficient to "top off" the tanks of relocating vehicles. It was found that if all automobiles are serviced on the average of every five days, the relocating first automobiles, representing three-fifths of the total fleet, can be serviced in three days. Since service stations operate substantially below capacity a considerable portion of the time, only a few of the risk area service stations need to be scheduled to provide continuing service.

C.4 Preattack Fuel Stockpiling

One of the important postattack implications of research on preattack crisis relocation planning guidelines is the need to expand output and stockpile fuel during the crisis relocation period. Based on data from one commonly-used attack pattern, it is estimated that approximately 30% of U.S. refining capacity will remain undamaged in the postattack period[C-9]. Therefore, fuel stockpiled in the host area prior to an attack will ease a possible severe shortage in the postattack period. Stockpiling of fuel in the host area should begin as soon as possible during crisis relocation.

Following evacuation, tank truck deliveries to all host-area gasoline stations will be increased both to meet the increased host-area fuel needs and to decrease vulnerability in the event of an attack.

Supplies will also be redirected to secondary bulk terminals within the host area. Secondary bulk storage in the host areas, however, may be relatively small. In the Colorado Springs host area, for example, if fuel is redirected to the host area, bulk terminals would be filled in less than three days, and storage tanks in host-area gasoline stations would require an additional five or six days to fill completely. Thus, if pre-evacuation production rates were continued, existing fuel storage capacity in this host area would be exceeded in little more than one week following crisis relocation. In the event that the crisis period extends beyond one week, therefore, a strategy of fuel stockpiling will require the creation of additional fuel storage capability in the host area. Possible alternatives for providing supplemental fuel storage facilities within the host area under extended crisis conditions include:

1. Building expedient storage facilities;
2. Constructing new bulk storage terminals;
3. Using underground storage; and
4. Filling the tanks of impounded automobiles.

Each of these alternatives is discussed briefly below.

Expedient Storage. One promising type of expedient storage facility suggested by industry officials entails the use of collapseable rubber-plastic containers. Such a storage facility has the advantage of requiring relatively short construction time. This type of storage, referred to as "embankment support storage," has thus far been developed for crude or petroleum products up to a capacity of 25,000 barrels. It is essentially a 185' X 100' X 14' rubber-plastic-treated fabric formed in the shape of a pillow,

and supported on all sides by earth embankments. In collapsed form, a crated container can be delivered to site on a semi-truck-trailer. Total construction time including earthwork, placement of container, roof, and pumps and values is about one week. The largest unit of this type (25,000 barrels) is still being tested by the U.S. Army. It does appear, however, that this type of storage may soon be available for such uses as those required under crisis relocation.

New Permanent Storage. Construction of new permanent bulk storage terminals is time-consuming. It is unlikely that a crisis would extend long enough to permit the construction of entirely new bulk storage facilities in the host area. Industry officials estimate that a 100,000-barrel new bulk terminal would require from three to six months to build, providing all materials were readily available. However, the steel for this type of facility is usually made to order, and can take from two months to one year or more to deliver depending upon other demands for steel.

Underground Storage. Underground storage is another possibility for petroleum product storage. Two European counties are known to store liquid petroleum products underground. In the United States (Colorado and elsewhere), natural gas is now stored underground and investigations have been underway for some time on the storage of crude underground. Salt domes which occur in a number of states can be made suitable for this type of liquid storage.

Tanks of Impounded Automobiles. Among the most readily available sources of storage for the excess fuel produced during an extended crisis period are the gasoline tanks of the automobiles used in the relocation itself. The bulk of these automobiles would be impounded following the relocation, and could be refilled from host-area outlets in the event of an extended crisis period. Automobiles could be released from impoundment on a scheduled basis during an extended crisis for the expressed purpose of refilling their fuel tanks, after which they would be reimpounded. This action would have the effect of freeing more fuel storage capacity within the host area and demonstrating to the automobile owners that fuel would be available for their use following the resolution of the crisis. Vehicles in use in the host area during an extended crisis should also be encouraged to "top off" their tanks frequently, keeping them as full as possible and freeing more fuel storage capacity within the host area.

In general, all existing and potential petroleum storage facilities in the host areas should be identified. Appropriate data (such as location, ownership, capacity, fuel category, number of loading bays, and pumping rates) should be obtained on each petroleum storage facility and included in the Fuel Annex of local plans.

C-5. Protecting Critical Facilities

Petroleum pipeline terminal facilities, including pumps, instrumentation, communications and storage tanks, are critical links in the fuel supply system network and should be protected where possible. Where such facilities are located on the fringes of target areas, they would not be completely destroyed but would receive light to moderate damage. Even light damage

could render these facilities inoperable in the first days and weeks after an attack, when fuel will be critically needed. In many instances, such facilities can be relatively easily protected with sandbags, steel mesh, or earth embankments. Protection measures for petroleum facilities are discussed by Stephens (Reference C-1); Appendix C-3 provides further data on protection measures. Discussions with petroleum industry officials will provide planners with data necessary to identify key pipeline facilities. Guidance for the protection of such facilities should be included in the Petroleum Annex, along with a set of priorities for protection reflecting both the importance of the facility and the anticipate level of damage at the site.

C-6. Probable Postattack Situation Summary

An analysis of the damage to national and local petroleum production and distribution facilities indicates that severe fuel shortages will probably follow a nuclear attack. The destruction of national and local refineries, storage facilities, and pipelines would necessitate changing patterns of distribution and implementing strict fuel use controls.

Only 30 percent of U.S. refinery and storage capacity is expected to survive a nuclear attack; therefore, it is anticipated that federal reallocations will effectively adjust local fuel supplies to 30 percent of preattack levels.

Following a crisis relocation prior to an attack, fuel requirements are expected to drop to between 35 and 40 percent of normal daily usage. As the nation's production capacity will far exceed consumption rates during

this period, excess supplies should be stockpiled in host-area storage tanks to alleviate anticipated postattack shortages. Rigid control and conservation measures such as rationing, vehicle impoundment, and restriction of unnecessary cargo shipments will be necessary following an attack. Introduction of these measures during the relocation period will allow these procedures to be tested under somewhat less harrowing circumstances and increase the supply of fuel available for stockpiling. Critical petroleum production and distribution facilities on the fringes of anticipated target areas should be protected with sandbags, steel mesh, and earth embankments during the relocation period.

Several alternative methods of alleviating a fuel shortage in the postattack period have been identified. These include:

- Assigning top priority to the repair of refineries and pipelines.
- Adjusting the fuel supply and distribution system to bypass damaged facilities. In the immediate postattack period, trucks could be used to bypass damaged refineries and pipelines and provide survivors with fuel from surviving supply points. In one case study in Colorado, it was determined that this adjustment would require a 41% increase in the mileage normally required to transport fuel.
- Introducing rigid control and conservation measures. Such measures include: (1) limiting cargo shipments to essential goods; (2) moving critical workers in buses and carpools; (3) impounding personal automobiles; and (4) introducing strict fuel rationing measures.

The available fuel supply will be the constraining element in the postattack management of the transportation system. In this regard, fuel shortages will be more critical than either vehicle losses or road damage. However, there should be sufficient fuel to support the movement of food and other essential commodities if its use is carefully controlled.

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A P P E N D I X   A

VEHICLES

EXHIBIT A.1-1

SAMPLE URBAN PUBLIC TRANSPORTATION DATA

1974 NATIONAL TRANSPORTATION STUDY

05 COLORADO

TABLE 7.1 - 1972 INVENTORY

URBAN PUBLIC TRANSPORTATION - BUS TRANSIT

AREA CODE	AREA NAME	MILES OF ROUTE	MILES OF LINE	VEHICLES NO.	VEHICLES AVG AGE	VEHICLES AVG SEATS	POUNDS POLLUTANTS PER VMT CO	NO	HC	ANNUAL PMT PER CAPITA	PMT PER SMT	FAT. /100 MILL PASS MILE	INJ. /100 MILL PASS MILE	% WITH PEAK IN BAND PCP	EMP	AVERAGE PEAK HOUR OP SPD. MPH	HDWY MIN	AVG FARE CENTS	ANNUAL PASS. TRIPS UNLKED MILL
030	BOULDER	33	33	6	8	45	0.0623	0.0036	0.0798	13	0.16	--	612.24	50	70	12	22.0	13	--
047	COLORADO SPRINGS	81	78	21	20	37	0.0623	0.0036	0.0799	13	0.21	--	66.66	29	65	12	48.7	24	1
058	DENVER	611	477	300	8	49	0.0550	0.0033	0.0718	22	0.05	--	319.32	55	90	13	11.5	32	20
174	PUEBLO	101	91	37	8	33	0.2110	0.0099	0.0780	37	0.16	--	123.51	62	85	9	25.0	14	1
	STATE TOTAL	826	679	364	8	46	0.0651	0.0037	0.0725	21	0.06	0.00	279.78	54	77	12	13.6	30	22

05 COLORADO

TABLE 7.2 - 1990 PLAN

URBAN PUBLIC TRANSPORTATION - BUS TRANSIT

AREA CODE	AREA NAME	MILES OF ROUTE	MILES OF LINE	VEHICLES NO.	VEHICLES AVG AGE	VEHICLES AVG SEATS	POUNDS POLLUTANTS PER VMT CO	NO	HC	ANNUAL PMT PER CAPITA	PMT PER SMT	FAT. /100 MILL PASS MILE	INJ. /100 MILL PASS MILE	% WITH PEAK IN BAND PCP	EMP	AVERAGE PEAK HOUR OP SPD. MPH	HDWY MIN	AVG FARE CENTS	ANNUAL PASS. TRIPS UNLKED MILL
030	BOULDER	45	45	25	6	35	0.0088	0.0009	0.0231	51	0.26	0.19	612.24	60	30	12	10.0	34	3
047	COLORADO SPRINGS	184	178	38	11	35	0.0088	0.0009	0.0231	39	0.39	0.19	66.66	40	75	15	18.0	33	7
058	DENVER	1535	1198	590	6	48	0.0095	0.0009	0.0226	226	0.40	0.19	319.32	55	95	12	10.0	17	167
174	PUEBLO	157	133	43	9	38	0.1144	0.0105	0.0162	69	0.29	1.07	123.51	75	75	9	26.2	15	3
	STATE TOTAL	1921	1554	696	6	46	0.0126	0.0012	0.0224	172	0.39	0.25	303.09	62	39	12	11.7	17	176

05 COLORADO

TABLE 7.3 - PERCENT CHANGE 1972-1990

URBAN PUBLIC TRANSPORTATION - BUS TRANSIT

AREA CODE	AREA NAME	MILES OF ROUTE	MILES OF LINE	VEHICLES NO.	VEHICLES AVG AGE	VEHICLES AVG SEATS	POUNDS POLLUTANTS PER VMT CO	NO	HC	ANNUAL PMT PER CAPITA	PMT PER SMT	FAT. /100 MILL PASS MILE	INJ. /100 MILL PASS MILE	% WITH PEAK IN BAND PCP	EMP	AVERAGE PEAK HOUR OP SPD. MPH	HDWY MIN	AVG FARE CENTS	ANNUAL PASS. TRIPS UNLKED MILL
030	BOULDER	36	36	316	-25	-22	-85.0	-75.0	-71.0	292	62	--	0.0	60	28	0	-54	161	--
047	COLORADO SPRINGS	127	128	80	-45	-5	-85.0	-75.0	-71.0	200	85	--	0.0	2	15	50	-63	17	200
058	DENVER	151	151	96	-25	-2	-84.0	-72.0	-68.0	927	700	--	0.0	72	14	-7	-13	[illegible]	735
174	PUEBLO	55	46	16	12	15	-45.0	6.0	-79.0	86	81	--	0.0	-8	-11	0	4	-15	200
	STATE TOTAL	132	128	91	-25	0	-80.5	-65.6	-69.1	688	547	0.0	10.9	52	15	-3	-13	-44	700

Source: Colorado 1974 National Transportation Study, Narrative Report, February 1974.

TABLE A.1-2

SUMMARY OF PUBLIC TRANSIT VEHICLE AVAILABILITY

	URBANIZED AREA POPULATION CLASSIFICATIONS (THOUSANDS)						
	2,000 and over	1,000 & under 2,000	500 & under 1,000	250 & under 500	100 & under 250	50 & under 100	Total, all areas
POPULATION INFORMATION:							
No. of Areas	10	13	29	40	80	69	241
Total Population (thousands)	59,309	18,041	20,097	13,120	12,417	5,205	128,189
BUS INFORMATION:							
No. of Buses	26,680	6,992	5,768	3,186	2,666	909	46,201
Average Seats/ Bus	47.6	48.7	45.7	43.5	38.7	35.4	46.4
Buses Per 1000 Population	.45	.39	.29	.24	.21	.17	36.0
RAPID RAIL INFORMATION:							
No. of Vehicles	10,129	101	35	23	0	0	10,288
Average Seats/ Vehicle	50.7	46.6	52.0	64.0	0	0	50.7
COMMUTER RAIL INFORMATION:							
No. of Vehicles	43,314	11	1	8	10	0	4,344
Average Seats/ Vehicle	104.6	70.1	24.0	110.0	89.0	0	104.5
SCHOOL BUS INFORMATION:							
No. of Buses	N/A	N/A	N/A	N/A	N/A	N/A	257,804*
TAXI INFORMATION:							
No. of Taxis	49,676	11,500	9,931	5,092	4,798	1,959	82,962
Taxis per 1000 Population	.84	.64	.49	.39	.39	.38	.65

*School bus totals reflect entire U.S., both urbanized and non-urbanized areas.

(Source: 1974 National Transportation Survey and Statistics on School Transportation)

EXHIBIT A.1-3

POPULATION DENSITY AND ZERO AUTO HOUSEHOLDS 1970

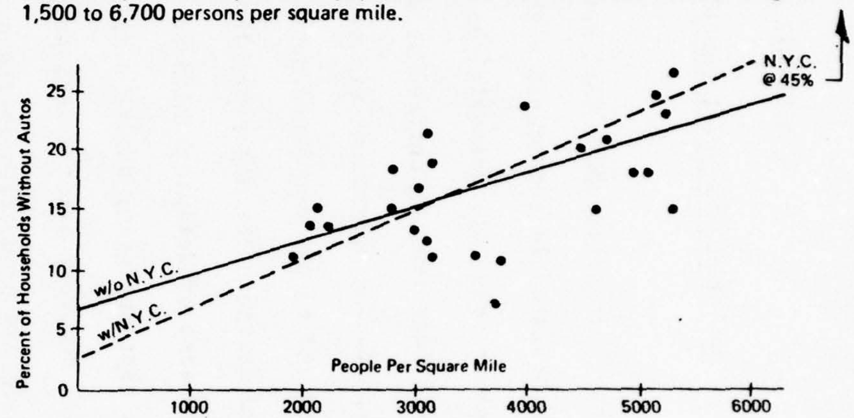
Area	Urbanized Area Population per Square Mile	Percent of Households Without Autos
All SMSAs	3,376	19%
33 Largest SMSAs (1)	4,237	22%
By Census Region		
Northeast (1)	5,550	32%
North Central (1)	3,636	19%
South	3,546	17%
West (1)	4,115	14%
By Density		
1 New York, New York (2)	6,683	45%
14 Newark, New Jersey	N/A	22%
22 Paterson-Clifton-Passaic, N.J.	N/A	14%
4 Philadelphia, Pa.-N.J.	5,349	23%
2 Los Angeles-Long Beach, Calif. (3)	5,313	15%
18 Anaheim-Garden Grove-Santa Ana	N/A	6%
3 Chicago, Illinois (4)	5,257	24%
31 New Orleans, Louisiana	5,227	26%
11 Baltimore, Maryland	5,103	23%
24 Buffalo	5,085	19%
7 Washington, D.C.-Md.-Va.	5,018	19%
25 Miami, Florida	4,715	20%
5 Detroit, Michigan	4,553	15%
6 San Francisco-Oakland, Calif.	4,387	19%
10 St. Louis, Mo.-Illinois	4,088	18%
8 Boston, Massachusetts	3,992	24%
30 San Jose, California	3,699	7%
27 Denver, Colorado	3,577	11%
21 Cincinnati, Ohio	3,314	19%
23 San Diego, California	3,148	11%
13 Houston, Texas	3,115	12%
9 Pittsburgh, Pennsylvania	3,095	21%
33 Portland, Oregon-Washington	3,092	14%
12 Cleveland, Ohio	3,033	17%
17 Seattle-Everett, Washington	2,997	13%
32 Tampa	2,969	15%
19 Milwaukee, Wisconsin	2,744	18%
20 Atlanta	2,696	14%
15 Minneapolis-St. Paul, Minn.	2,363	14%
26 Kansas City, Mo.-Kansas	2,234	15%
29 Indianapolis, Indiana	2,152	14%
16 Dallas, Texas	1,986	11%
28 San Bernardino-Riverside-Ontario	1,884	10%

In this and the following table (I-18), population density statistics are given for the urbanized area rather than the entire SMSA. See table (I-4) for a comparison of SMSA and urbanized area densities in individual cities.

In 1970, 19% of all households in all SMSAs were still without autos. In the 33 largest SMSAs, the figure was 22%.

There is a definite relationship between populations density and the number of households without autos. Each point on the graph shows the population density and percent of households without autos for one of the 33 largest SMSAs. The lines show the "average" relationship (actually, the linear regression) between density and auto ownership. Since the percent of households without autos in New York City is so far above the range of observations for other cities, averages with and without New York City are included in order to avoid challenges about the statistical validity of the regression.

While high densities and high percentages of households without autos clearly occur together, it is not necessarily true that either causes the other. Nor will the regression relationship necessarily hold for population densities outside the observed range of 1,500 to 6,700 persons per square mile.



(1) Urbanized area density data for these areas includes appropriate consolidated area data rather than SMSA data.

(2) Urbanized area density data for this area represents the New York, New York-Northeastern New Jersey consolidated area. The SMSAs of Newark, New Jersey and Paterson-Clifton-Passaic, New Jersey are included in this area.

(3) Urbanized area density data for this area represents the Los Angeles-Long Beach, California consolidated area. The SMSA of Anaheim-Garden Grove-Santa Ana, Calif. is included in this area.

(4) Urbanized area density data for this area represents the Chicago, Illinois-Northwestern Indiana consolidated area.

Source: Urban Transportation Fact Book, Motor Vehicle ManufacturersAssociation of the U.S., Inc.1974.

APPENDIX A.1.4

NATIONAL AND LOCAL ESSENTIAL FACILITIES LISTS

It has been noted above that several "essential" industry lists have been prepared in accordance with various criteria. There is apparent agreement among all criteria, however, that food manufacturers, fuel suppliers (where fuel is defined as energy), pharmaceutical manufacturers, and transportation operations are essential to the life support of the population and to the continued operation of the productive capacity of the United States. The major problems of identifying critical facilities lie in the area of defining which portions of the production capacity should be kept operating during a crisis relocation and are essential to post-attack recovery after a nuclear exchange, and even which are essential to maintain production in the event of a conventional war of unknown magnitude. Obviously, one master "Nationally Essential Facilities" list cannot be developed to meet these varying requirements. Therefore, it was decided to concentrate on identifying the facilities that should be kept in operation during a crisis relocation period of 14-30 days.[A-11]

It should be noted that manufacturing establishments and suppliers. raw or semi-finished materials to them have been considered as nationally essential facilities. Because of the difficulty in determining the location of such facilities as:

- Petroleum bulk stations and terminals;
- Truck "redistribution" facilities;
- Railroad marshaling yards; and
- Mining and extraction processing facilities,

INTERIM LIST OF NATIONALLY ESSENTIAL INDUSTRIES IDENTIFIED BY STANDARD INDUSTRIAL CLASSIFICATION CODES

Industry Number (SIC)	Title
1211	Bituminous Coal
1311	Crude Petroleum & Natural Gas
1321	Natural Gas Liquids
1472	Barite
1473	Fluorspar
1474	Potash, Soda, Borate Minerals
1475	Phosphate Rock
1476	Rock Salt
1479	Chemical & Fertilizer Materials
2611	Pulp Mills
2621	Paper Mills
2643	Paper Bags
2647	Sanitary Paper Products
2651	Folding Paperboard Foxes
2654	Sanitary Food Containers
2711	Newspapers, Publishing
2812	Alkalines and Chlorine
2819	Industrial Inorganic Chemicals, NEC
2822	Synthetic Rubber
2831	Biological Products
2833	Medical Chemicals & Botanical Products
2834	Pharmaceutical Preparations
2841	Soaps and Detergents
2842	Special Sanitary Preparation
2869	Industrial Organic Chemicals, NEC
2871	Fertilizers
2873	Nitrogenous Fertilizer
2879	Agricultural Pesticides & Chemicals
2899	Chemicals & Chemical Preparations, NEC
2911	Petroleum Refining

Industry Number (SIC)	Title
3011	Tires and Inner Tubes
3041	Rubber, Plastics Hose and Belting
3221	Glass Containers
3312	Blast Furnaces (Including Coke Ovens)
3317	Steel Pipe and Tubes
3411	Metal Cans
3423	Hand Edge Tools, Except Machine Tools and Hand Saws
3523	Farm Machinery and Equipment
3531	Construction Machinery and Equipment
3546	Power-Driven Hand Tools
3623	Welding Appartus, Electric
3641	Electric Lamps
3841	Surgical and Medical Instruments and Appartus
3842	Orthopedic, Prosthetic, and Surgical Appliances and Supplies
4011	Railroads, Line Haul
4213	Trucking, Except Local
4231	Maintenance Facilities for Motor Freight
4612	Crude Petroleum and Pipelines
4613	Refined Petroleum Pipelines
4619	Pipelines (Other)
4811	Telephone Communications
4821	Telegraph Communications
4899	Communication Services (Other)
4911	Electric Services
4922	Natural Gas Transmission
4923	Natural Gas Transmission and Distribution
4924	Natural Gas Distribution

they have not been included as candidates for inclusion in the NEF list. Many of those in the last category are located in sparsely populated areas; however, some (such as oil extraction) are located in populated areas.

A major problem for inclusion of any facility of a NEFL is the total output required for the industry during the evacuation period. There is doubt that demand for goods will drop; the extent of the drop can only be guessed. For example, gasoline consumption will be cut drastically because private automobile use will be virtually nonexistent; fuel consumption will drop because some industries will be shut down; steel demand will drop for the same reason. Thus, for example, the question posed is how many of the refineries and steel mills in the evacuated areas need be kept in operation. Obviously, steel can be shipped away from the areas at hazard and stock-piled; but there is an absolute limit to fuel storage space which is rather easily reached when consumption falls by even a few percent.

Criteria, Methodology and an Explanation of the Local Vital Industries SIC Table

"The definition of 'Local Vital Facilities' is those facilities in a local area where production must be maintained for the life support of the population of that city prior to, during and for the duration of the evacuation. This definition limits the facilities to those contributing to the production items that fulfill basic human needs -- ostensibly food and shelter.

Based on the four-digit SIC code industries, a table was developed marking the local vital industries (based on the above definition). The following pages outline specific criteria for inclusion and exclusion, and explain the limitations of the table. The general criteria (outlined by the above definition), the criteria for the inclusion of specific industries on the local vital industries SIC list, and the choice of specific plants on the local vital facilities lists were determined judgmentally by the author, as a result of discussions with DCPA staff officers, IDA and JHK & Associates staff members, local and state authorities, and city planners of Austin and San Antonio, Texas, and a brief process analysis of certain industries."[A-12]

Criteria for Inclusion in the Local Vital Industries SIC List

The following explanations outline entire sectors included in the High-Risk Area and special cases where inclusion might seem questionable. It is assumed that all facilities in the Host Jurisdiction will continue to operate, subject to availability of inventory:

(1) All industrial sectors that input to the production of food are included. There are, nevertheless, exceptions to this rule--notably production of foods with little nutritional value (e.g., candy and carbonated soft drinks). More often, only a few products of an SIC group are included, while a great number of products under the same SIC group are excluded. An example of this is SIC 2099: Food Preparations, NEC. Yeast, which is a local vital product, comes under this SIC; therefore, the group number is included, although other products that also come under this group (e.g., spaces, catsup, and chutney) are not vital products. Thus, in the San Antonio sample lists, not all plants with the SIC number 2099 have been included, although the number is on the Local Vital Industries SIC list.

(2) All energy-producing industries (electric companies, petroleum refineries) are included in the Local Vital Industries SIC and facilities lists. These will also show on the National Essential Facilities lists.

(3) Wholesale trade facilities and companies are included where they pertain to the distribution of food, drugs, and other vital items.

(4) All facilities that produce pastries are included, on the assumption that they are easily converted to bread production.

(5) Industries producing beer are included, on the assumption that they provide a good source of drinking water which could be bottled during a crisis.

(6) All transportation SIC groups are included, although regular routes and business-as-usual would be different.

(7) Retail stores are indicated as being operable in Host Jurisdictions only. Even though the probability exists that all such establishments will continue to operate in these low-risk areas until their stocks are depleted, these specific SIC establishments are highlighted to ensure that the local authorities will arrange for necessary controls and replenishments of their essential life-support goods.[A-12]

APPENDIX B

Roads

TABLE B.1

SAMPLE TRAFFIC VOLUME STUDY, STATE OF COLORADO

State Highway No. 115: From Jct. SH 50 in Canon City, to Jct. SH 85 and SH 122 South of Colorado Springs, via Florence and Penrose.

Section Termini	System	Length	Factors		Year	Section Volume	Pass. Cars		Trucks			Vehicle Miles Travel
			20-Yr	DHV			Colo.	For.	P.U.	S.U.	Comb.	
West Jct. SH 50												
South City Limits	**FAS**	UM			1952	-						
Canon City		0.7	1.5	.11	1972	8650	5511	308	2353	432	46	6,060
Southeast Urban Limits		U			1952	1800	1105	33	569	77	16	
Canon City		3.1	1.5	.12	1972	3000	1758	308	750	138	46	9,300
Northwest City Limits		R			1952	1700	1042	33	536	73	16	
Florence		4.0	1.5	.12	1972	3450	2057	308	878	161	46	13,800
		RM			1952	-						
West Jct. SH 67		0.8	1.5	.12	1972	4200	2555	308	1091	200	46	3,360
		RM			1952	-						
East Jct. SH 67		0.3	1.5	.12	1972	5050	3202	320	1227	251	50	1,520
East City Limits		RM			1952	-						
Florence		0.6	1.5	.12	1972	4700	2738	208	1318	336	100	2,820
		R			1952	1500	916	33	471	64	16	
Jct. SH 120		1.4	1.5	.12	1972	2700	1491	208	718	183	100	3,780
		R			1952	800	468	62	148	95	27	
East Jct. SH 50	**FAS**	2.9	1.5	.12	1972	2050	1085	203	482	127	153	5,950
Jct. Local Road at	**FAP**	R			1952	1150	613	232	146	106	53	
Penrose		0.8	1.5	.16	1972	4050	1761	1141	792	170	186	3,240
Jct. Local Road (Main		R			1952	1000	507	232	121	87	53	
Entrance to Fort Carson)	**FAP**	27.6	1.5	.16	1972	3450	1373	1141	618	132	186	95,220

(Source: Reference B-3)

(Table B.1, Con't.)

State Highway No. 115: From Jct. SH 50 in Canon City, to Jct. SH 85 and SH 122 South of Colorado Springs.

Section Termini	System	Length	Factors		Year	Section Volume	Pass. Cars		Trucks			Vehicle Miles Travel
			20-Yr	DHV			Colo.	For.	P.U.	S.U.	Comb.	
South Urban Limits	FAP	R			1952	8000	4424	2429	620	433	94	
Colorado Springs		0.4	1.5	.11	1972	12500	5863	4935	1196	284	222	5,000
South City Limits		U			1952	-						
Colorado Springs		1.9	1.5	.11	1972	16000	8658	4935	1766	419	222	30,400
City Limits		UM			1952	-						
Colorado Springs		0.8	1.5	.11	1972	19000	11054	4935	2255	534	222	15,200
		U			1952	-						
Jct. SH 85 and SH 122	FAP	0.4	1.5	.11	1972	21000	12650	4935	2581	612	222	8,400
Subtotal Route 115	FAP	31.9										157,460
Subtotal Route 115	FAS	13.8										46,590
Total Route 115		45.7										204,050

(Source: Reference B-3)

TABLE B.2

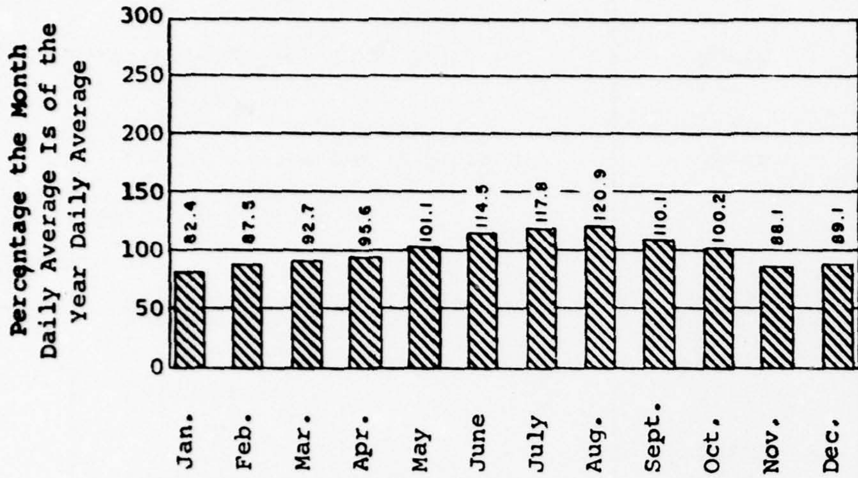
STATE OF COLORADO

SAMPLE PERMANENT STATION TRAFFIC DATA

Station: 41 (continued)

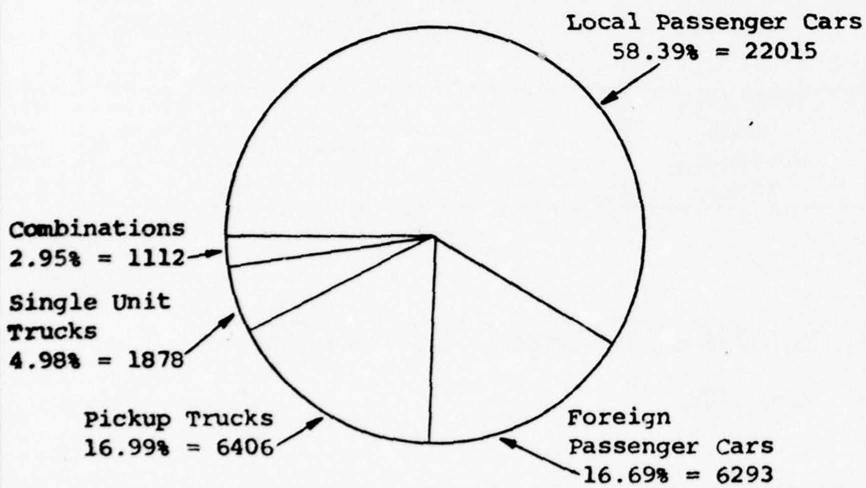
1972 ADT = 37704

PERCENT ADM IS OF ADT



VEHICLE CLASSIFICATION

Average Daily Volumes for Year



HOURLY VOLUMES IN ORDER OF MAGNITUDE

Order	Day	Date	Hour	Volume	Percent of ADT
1	Fri	7-21	4-5P	4811	12.8
2	Wed	11-22	4-5P	4636	12.3
3	Fri	8-18	4-5P	4611	12.2
4	Fri	4-28	4-5P	4586	12.2
5	Fri	9-29	4-5P	4546	12.1
6	Fri	8-11	4-5P	4493	11.9
7	Fri	9-1	4-5P	4476	11.9
8	Fri	10-13	4-5P	4472	11.9
9	Wed	8-9	4-5P	4452	11.8
10	Fri	8-4	4-5P	4440	11.8
15	Fri	7-7	4-5P	4396	11.7
20	Fri	5-26	4-5P	4380	11.6
25	Mon	8-7	4-5P	4313	11.4
30	Thu	8-10	4-5P	4286	11.4
35	Mon	7-31	4-5P	4230	11.2
40	Fri	9-15	4-5P	4205	11.2
45	Fri	9-8	4-5P	4191	11.1
50	Tue	10-3	4-5P	4173	11.1
60	Tue	6-20	4-5P	4122	10.9
70	Wed	8-30	4-5P	4084	10.8
80	Fri	4-7	4-5P	4049	10.7
90	Thu	7-6	4-5P	4007	10.6
100	Fri	9-1	5-6P	3967	10.5
125	Mon	10-16	4-5P	3875	10.3
150	Fri	2-11	4-5P	3806	10.1
175	Wed	10-11	4-5P	3737	9.9
200	Wed	8-16	3-4P	3682	9.8

Source: Reference 9

TABLE B-3

HOST AREA RAIL TERMINALS WHICH COULD BE USED FOR INTERMODAL TRANSFER

Railroad	Track Direction from Risk Area	Location
Denver		
Burlington Northern-Colorado and Southern	North West	Loveland and Ft. Collins, Larimer County Tenville and Hudson, Weld County
Denver Rio Grande & Western	West South	Winter Park and Fraser, Grand County Monument in El Paso County
Union Pacific	North East	Ault and Nunn, Weld County Limon, Lincoln County
Atchison, Topeka & Santa Fe	South	Monument, El Paso County
Colorado Springs		
Denver Rio Grande & Western-Chicago Rock Island & Pacific	South West	Walsenburg, Huerfano County Limon, Lincoln County
Atchisor, Topeka & Santa Fe	North	Monument, El Paso County

APPENDIX C

Fuel

TABLE C.1-1

SURVEY OF OPERATING REFINERIES IN THE U.S. AND COLORADO

(STATE CAPACITIES AS OF JAN. 1, 1975)

State	No. plants	Crude capacity* b/cd	Crude capacity* b/sd
Alabama	3	34,375	37,947
Alaska	4	66,050	69,520
Arizona	1	4,000	4,211
Arkansas	4	60,715	62,536
California	36	1,900,640	1,985,140
Colorado	3	60,000	62,500
Delaware	1	140,000	150,000
Florida	1	5,700	6,000
Georgia	2	18,000	19,789
Hawaii	2	85,000	89,473
Illinois	11	1,168,150	1,224,658
Indiana	8	563,275	595,973
Kansas	11	447,180	466,129
Kentucky	3	164,000	168,900
Louisiana	19	1,729,575	1,802,149
Maryland	2	26,500	28,211
Michigan	6	149,082	151,379
Minnesota	3	199,300	204,000
Mississippi	5	289,500	304,737
Missouri	1	107,000	107,000
Montana	8	157,206	164,227
Nebraska	1	5,000	5,500
New Jersey	4	539,000	562,764
New Mexico	7	103,061	111,135
New York	2	111,385	114,500
North Dakota	3	58,658	60,263
Ohio	7	589,770	614,500
Oklahoma	12	499,815	515,145
Oregon	1	14,000	14,740
Pennsylvania	11	757,020	796,415
Rhode Island	1	7,500	10,000
Tennessee	1	43,900	44,800
Texas	45	3,929,430	4,096,965
Utah	6	143,000	117,068
Virginia	1	53,000	54,000
Washington	7	364,000	379,816
West Virginia	3	19,750	20,500
Wisconsin	1	45,000	46,400
Wyoming	12	186,870	194,660
Total	259	14,845,407	15,463,650

*State totals include figures converted to calendar-day or stream-day basis.

Refineries in Colorado

Plant	Location	Crude Capacity (bbl/cal. day)	Gasoline Output Capacity (bbl/cal. day)
Conoco	Denver	30,000	14,500
Refinery Corp.	Denver	20,500	10,000
Gary Western	Grand Junction	9,500	6,900
	TOTAL	60,000	31,400

Source: The Oil and Gas Journal, April 7, 1975 and SYSTAN Interviews.

TABLE C1-2

MILEAGE OF PRODUCT PIPELINES IN THE UNITED STATES

AS OF JANUARY 1, 1971

(Miles)

State	Size (inches)												Total	
	Under 4	4 1/	6 2/	8	10	12	14	16	18	20	22	24 (and over)	Jan. 1, 1971	Jan. 1, 1968
Alabama	–	–	36	85	18	402	–	2	310	–	–	290	1,143	1,049
Alaska	–	–	8	–	–	–	–	–	–	–	–	–	8	–
Arizona	–	–	173	241	–	280	–	–	–	–	–	–	694	696
Arkansas	7	20	37	57	234	248	–	1	–	297	–	–	901	901
California	140	342	495	943	382	302	175	62	–	–	–	–	2,841	2,403
Colorado	–	–	411	87	–	–	–	–	–	–	–	–	498	502
Connecticut	–	–	22	–	6	64	–	–	–	–	–	–	92	91
Delaware	–	–	–	–	–	–	–	–	–	–	–	3	3	3
Florida	–	–	26	24	37	–	–	–	–	–	–	–	87	35
Georgia	–	42	197	685	218	104	148	–	12	–	–	322	1,728	1,567
Idaho	–	13	–	548	79	–	–	–	–	–	–	–	640	639
Illinois	1	1	246	1,272	516	807	438	160	3	–	–	–	3,444	3,101
Indiana	6	5	103	1,009	456	300	202	102	–	195	–	–	2,378	2,137
Iowa	6	2	1,456	1,157	292	850	–	84	–	–	–	–	3,847	3,103
Kansas	–	206	1,261	2,642	972	710	–	185	–	–	–	–	5,976	4,590
Kentucky	–	–	49	–	1	–	–	–	–	–	–	–	50	49
Louisiana	7	241	477	502	351	225	–	–	112	142	–	202	2,259	2,069
Maine	–	–	124	–	–	–	–	–	–	–	–	–	124	325
Maryland and District of Columbia	–	–	59	24	–	38	–	–	–	–	–	98	219	235
Massachusetts	–	28	190	10	–	14	–	–	–	–	–	–	242	239
Michigan	1	–	259	472	282	166	–	230	–	–	–	–	1,410	1,271
Minnesota	–	14	424	906	137	291	–	–	–	–	–	–	1,772	1,759
Mississippi	–	–	–	90	–	521	–	–	332	–	–	180	1,123	924
Missouri	10	–	119	1,623	822	412	–	62	–	70	–	–	3,118	3,021
Montana	2	4	141	379	443	–	–	54	–	–	–	–	1,023	967
Nebraska	–	12	1,222	890	38	151	–	–	–	–	–	–	2,313	1,916
Nevada	–	8	82	237	–	1	–	–	–	–	–	–	328	331
New Jersey	2	–	136	39	13	43	79	138	2	–	–	97	549	545
New Mexico	82	–	228	732	–	163	–	–	–	–	–	–	1,205	1,130
New York	1	17	384	392	187	71	84	12	–	–	–	–	1,148	1,130
North Carolina	–	–	131	261	108	18	169	–	–	–	–	147	834	833
North Dakota	–	2	81	137	198	–	–	–	–	–	–	–	418	483
Ohio	4	81	868	1,323	726	352	94	49	–	34	–	–	3,531	3,333
Oklahoma	1	335	789	1,275	481	432	–	1	–	–	–	177	3,491	3,208
Oregon	–	3	61	619	–	–	6	–	–	–	–	–	689	402
Pennsylvania	31	112	1,392	1,226	285	185	290	146	114	77	–	155	4,013	4,027
Rhode Island	3	–	14	–	–	–	–	–	–	–	–	–	17	17
South Carolina	–	–	9	240	104	10	102	–	–	–	–	170	635	567
South Dakota	–	–	564	54	–	22	–	–	–	–	–	–	640	575
Tennessee	–	–	–	247	118	–	–	–	–	–	–	–	365	365
Texas	373	1,280	3,770	3,678	1,968	1,376	305	68	34	92	–	110	13,054	10,608
Utah	–	1	11	292	7	2	–	–	–	–	–	–	313	488
Virginia	–	–	54	155	13	109	208	54	–	–	9	220	822	807
Washington	2	1	217	244	14	22	141	121	–	–	–	–	762	608
West Virginia	–	–	7	1	–	–	–	–	–	–	–	–	8	7
Wisconsin	–	–	72	172	109	41	–	72	–	–	–	–	466	464
Wyoming	23	1	327	664	170	–	–	–	–	–	–	–	1,185	1,009
Total January 1, 1971	702	2,771	16,732	25,634	9,785	8,732	2,441	1,603	919	907	9	2,171	72,406	–
Total January 1, 1968	641	2,419	16,002	22,822	8,187	7,189	2,129	1,441	937	1,075	9	1,678	–	64,529

1/ Includes a small amount of 5-inch pipe.

2/ Includes a small amount of 7-inch pipe.

Source: USBM

TABLE C2-1: Percent of vehicle-miles of travel by trip purpose and occupation of driver.

Trip purpose	Occupational groups									All drivers
	Professional and semi-professional	Farmers and farm managers	Other proprietors, managers and officials	Store and office clerks and salesmen	Craftsmen, foremen, skilled laborers, etc.	Operators semiskilled and unskilled workers and laborers	Protective services	Personal services	Other	
				Purpose within occupational groups						
Earning a living										
Home-to-work	38.6	8.2	39.4	45.5	41.5	42.6	36.4	49.4	5.0	33.7
Related business	9.7	16.1	15.9	12.7	5.4	4.4	6.5	4.6	4.1	7.9
Subtotal	48.3	24.3	55.3	58.2	46.9	47.0	42.9	56.0	9.1	41.6
Family business										
Shopping	5.6	8.5	3.2	5.9	5.5	6.0	10.2	6.8	15.1	7.5
Medical and dental	7.1	8.1	4.2	1.2	0.5	1.0	1.0	1.3	3.6	1.6
Other	9.1	19.2	7.7	7.7	8.1	10.9	8.2	12.0	19.2	10.2
Subtotal	15.8	35.8	15.1	14.8	14.1	17.9	19.4	20.1	40.9	19.3
Civic, educational and religious	3.8	3.8	1.4	4.0	1.8	3.3	3.9	5.3	12.5	4.9
Social and recreational										
Pleasure driving	1.8	0.8	3.0	2.6	4.8	2.6	6.0	1.4	3.0	3.1
Vacations	3.2	*	0.3	0.9	2.8	4.3	2.7	*	3.1	2.5
Visiting friends and relatives	10.5	15.8	8.6	8.9	16.4	13.0	9.3	11.2	16.3	12.1
Other	15.5	16.0	15.1	8.9	12.9	11.0	15.7	5.8	13.1	15.3
Subtotal	31.0	32.6	27.0	21.3	36.9	30.9	33.7	18.4	35.5	33.0
Other	1.1	3.5	1.2	1.7	0.3	0.9	0.1	0.2	2.0	1.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0 1/
				Purpose by occupational groups						
Earning a living										
Home-to-work	19.4	0.5	11.4	23.2	16.2	18.8	2.8	5.3	2.4	100.0
Related business	20.5	3.9	19.3	27.3	8.9	8.1	2.1	2.1	7.8	100.0
Subtotal	19.6	1.1	13.0	24.0	14.8	16.7	2.6	4.7	3.5	100.0
Family business										
Shopping	12.7	2.2	5.5	13.7	9.6	11.9	3.5	3.3	37.6	100.0
Medical and dental	10.6	*	18.5	11.8	4.1	8.9	1.4	2.7	42.0	100.0
Other	14.9	3.6	7.3	12.8	10.4	15.7	2.0	4.2	29.1	100.0
Subtotal	13.7	3.6	7.6	13.1	9.5	13.0	2.5	3.7	33.3	100.0
Civic, educational and religious	14.4	1.6	3.0	15.2	5.3	11.1	1.6	4.[illegible]	43.5	100.0
Social and recreational										
Pleasure driving	11.2	0.5	10.9	16.1	23.0	14.0	5.6	1.9	16.8	100.0
Vacations	23.5	*	1.1	7.0	15.9	28.3	3.0	*	21.2	100.0
Visiting friends and relatives	13.2	2.6	7.2	13.0	18.4	16.4	2.0	3.5	21.7	100.0
Other	22.0	2.6	12.3	12.9	14.3	13.7	3.4	1.8	17.0	100.0
Subtotal	18.3	2.2	9.2	12.8	16.9	16.0	3.1	2.3	19.2	100.0
All purposes	17.7	2.0	10.2	18.0	13.8	15.5	2.7	3.8	16.3	100.0

* Data insufficient for analysis.

1/ 775,940,000,000 vehicle-miles of travel

SOURCE: Based upon unpublished table T-2 from the Nationwide Personal Transportation Survey conducted by the Bureau of the Census for the Federal Highway Administration, 1969-1970.

TABLE C.2-2

CRISIS RELOCATION TRANSPORTATION FUEL REQUIREMENTS
(Thousands of Gallons Per Day)

USAGE CATEGORY	RISK AREA			HOST AREA			TOTAL		
	Before Relocation	During Relocation	After Relocation	Before Relocation	During Relocation	After Relocation	Before Relocation	During Relocation	After Relocation
Cargo Trucks	59.18	50.79	42.41	25.20	21.11	17.04	84.38	71.90	59.45
Intercity	35.35	28.28	21.21	20.34	16.27	12.20	55.69	44.55	33.41
Local	23.83	22.51	21.20	4.84	4.84	4.84	28.69	27.35	26.04
Personal Transport	269.59	68.49	32.04	99.31	110.80	147.25	368.90	179.29	179.29
Work	112.69	32.04	32.04	41.51	41.51	41.51	154.20	73.55	73.55
- Risk Area Residents	112.69	32.04	32.04	0	0	0	112.69	32.04	32.04
- Host Area Residents	0	0	0	41.51	41.51	41.51	41.51	41.51	41.51
Family Business	52.30	26.15	0	19.26	45.41	71.56	71.56	71.56	71.56
- Risk Area Residents	52.30	26.15	0	0	26.15	52.30	52.30	52.30	52.30
- Host Area Residents	0	0	0	19.26	19.26	19.26	19.26	19.26	19.26
Social & Recreation	91.93	10.30	0	33.86	23.88	34.18	125.79	34.18	34.18
- Risk Area Residents	91.93	10.30	0	0	10.30	20.60	91.93	20.60	20.60
- Host Area Residents	0	0	0	33.86	13.58	13.58	33.86	13.58	13.58
Education	12.67	0	0	4.67	0	0	17.34	0	0
- Risk Area Residents	12.67	0	0	0	0	0	12.67	0	0
- Host Area Residents	0	0	0	4.67	0	0	4.67	0	0
Personal Relocation	---	109.58	----	---	42.30	---	---	151.88	---
TOTAL	328.77	228.89	74.45	124.51	174.21	164.29	453.28	403.10	238.74

TABLE C.2-3

U.S. TRANSPORTATION ENERGY - 1970

MODE	TRANSPORT WORK (pass. mi. or ton mi.)	LOAD FACTOR	ENERGY INTENSIVENESS (Btu/pass. mi. or Btu/ton mi.) (at current load factor)		ENERGY CONSUMPTION (10^{15} Btu) Subtotals	Additive Totals
PASSENGER SERVICE						
Auto: Urban	.69 x 10^{12}	1.4 pass/veh.	7550	(12.1 mpg)	5.2	
Intercity	1.04	2.5	3250	(16.0 mpg)	3.4	
(Small cars) ALTERNATE BREAKDOWN	(.27)	1.9	3220	(21.2 mpg)	(.87)	
(Stnd. & compact cars) ALTERNATE BREAKDOWN	(1.46)	1.9	5300	(12.9 mpg)	(7.73)	
AUTO MODE	1.73	1.9	4980	(13.6 mpg)	8.6	8.6
Light Truck	.08	1.4	9000	(10.1 mpg)		.72
Air: Short haul (<500 mi.)	.018		12200		.22	
Long haul (>500 mi.)	.101		8720		.88	
AIR MODE	.119	49%	9300		1.10	1.10
Bus: Urban	.017	10 pass/veh.	2940	(4.4 mpg)	.05	
Intercity	.028	22	1070	(5.5 mpg)	.03	
School	.052	25	770	(6.75 mpg)	.04	
BUS MODE	.097	19.2	1240	(5.5 mpg)	.12	.12
Rail: Urban	.007	25%	4300		.03	
Intercity	.011	37%	2730		.03	
RAIL MODE	.018		3300		.06	.06
ALL PASSENGER SERVICE	2.044 x 10^{12} pass. mi.		5250 Btu/pass. mi.			10.6
FREIGHT SERVICE						
Truck: Single Units	.15	1.09 ton mi./veh. mi	10650 Btu/ton mi.		1.6	
Combinations	.35	9.21	3440		1.2	
(Motor Carrier) ALTERNATE BREAKDOWN	(.39)					
(Private Truck) ALTERNATE BREAKDOWN	(.11)					
TRUCK MODE	.50	2.63	5600		2.8	2.8
Rail	.77		675			.52
Air	.004		37500			.15
Pipeline	.43		420			.18
Waterway	.60		750			.45
ALL FREIGHT SERVICE	2.304 x 10^{12} ton mi.		1780 Btu/ton mi.			4.1
OTHER						
General Aviation						.10
Recreational Vehicles						.20
Military						1.5
TOTAL TRANSPORTATION						16.5

(Source: Reference C-7)

TABLE C.2-4

DISTRIBUTION OF ENERGY WITHIN THE TRANSPORTATION SECTOR

	% of Total Energy	
	1960	1970
1. Automobiles		
urban	25.2	28.9
intercity	27.6	26.4
	(52.8)	(55.3)
2. Aircraft		
freight	0.3	0.8
passenger	3.8	6.7
	(4.1)	(7.5)
3. Railroads		
freight	3.7	3.2
passenger	0.3	0.1
	(4.0)	(3.3)
4. Trucks		
intercity freight	6.1	5.8
other uses[a]	13.8	15.3
	(19.9)	(21.1)
5. Waterways, freight	1.1	1.0
6. Pipelines	0.9	1.2
7. Buses	0.2	0.2
8. Other[b]	17.0	10.4
Total	100.0%	100.0%
Total Transportation Energy Consumption (10^{15})	10.9	16.5 Btu

[a]Data from Federal Highway Administration, Highway Statistics.

[b]Includes passenger traffic by boat, general aviation, pleasure boating, and non-bus urban mass transit, as well as the effects of historical variations in modal energy-efficiencies.

(Source: Reference C-7)

TABLE C.2-5

DISTRIBUTION OF ENERGY WITHIN THE

U.S. TRANSPORTATION SECTOR

	Percent of Total Energy		
	1950	**1960**	**1970**
1. Automobiles	(38.0)	(51.4)	(54.2)
urban	22.3	29.2	34.2
intercity	15.7	22.2	20.0
2. Trucks	(16.6)	(19.8)	(21.1)
intercity freight	4.7	7.5	6.9
other	11.9	12.3	14.2
3. Railroads	(25.2)	(4.9)	(3.3)
freight	22.4	4.3	3.1
passenger	2.8	0.6	0.2
4. Airplanes	(1.7)	(7.5)	(10.8)
passenger	0.5	2.0	5.6
freight	0.1	0.3	0.8
general aviation	0.1	0.3	0.6
military	1.0	4.9	3.8
5. Buses	(1.1)	(1.0)	(0.8)
urban	0.8	0.5	0.3
intercity	0.2	0.3	0.25
school	0.1	0.2	0.25
6. Non-bus urban mass transit	1.0	0.3	0.2
7. Waterways, freight	3.6	2.8	2.5
8. Pipelines	0.7	0.9	1.2
9. Other[a]	12.1	11.4	5.9
Total Transportation Energy Consumption[b] (10^{15} Btu)	8.7	10.9	16.5

[a]"Other" (the difference between Bureau of Mines totals and the sum of lines 1-8) includes passenger traffic by boat, pleasure boating, nonfuel uses of energy (lubricants, greases), nonaviation military fuel uses, and errors due to the use of approximations and assumptions.

[b]As reported by the Bureau of Mines.

(Source: Reference C-7)

TABLE C.2-6

INTERCITY FREIGHT TRANSPORT DATA FOR 1970

	EI Actual (Btu/TM)	Price (¢/TM)	Haul Length (miles)	Speed (mph)
Pipeline	450	0.27	300	5
Railroad	670	1.4	500	20
Waterway	680	0.30	1,000	—
Truck	2,800	7.5	300	~40
Airplane	42,000	21.9	1,000	400

TABLE C.2-7

PASSENGER TRANSPORT DATA FOR 1970

	EI (Btu/PM)		Load Factor (%)	Price (¢/PM)	Fatality Rate (deaths per 10^8 PM)	Haul Length (miles)	Speed (mph)
	Actual	100% LF					
			Intercity				
Bus	1600	740	46	3.6	0.10	100	45
Railroad	2900	1100	37	4.0	0.09	80	40
Automobile	3400	1600	48	4.0	3.25	50	~50
Airplane	8400	4100	49	6.0	0.13	700	400
			Urban				
Mass transit	3800	760	20	8.3	0.26	3	~15
Automobile	8100	2300	28	9.6	2.11	6	~20

(Source: Reference C-7)

TABLE C.2-8

PROJECTED UNITED STATES TRANSPORTATION DEMAND AND ENERGY USE

Gallons and Passenger Miles (billions)	For a Typical Year 1965-1970 Period			With Present Trends 1990-2000 Period			With Energy Conservation 1990-2000 Period		
	Passenger Miles	Gal. of Fuel	PM/g, NPE	Passenger Miles	Gal. of Fuel	PM/g, NPE	Passenger Miles	Gal. of Fuel	PM/g, NPE
Short-haul air	30	2.0	15	90	6.0	15	30	1.0	30
Long-haul air	60	3.0	20	330	16.5	20	120	4.0	30
Intercity bus	25	0.3	83	50	0.5	100	250	2.0	125
Passenger trains	13	0.2	65	30	0.4	75	350	2.8	125
Intercity driving	900	26.0	35	2000	50.0	35	900	15.0	60
Passenger auto-trains	–	–	–	–	–	–	850	8.5	100
Intercity passenger	1028	31.5	32	2500	73.4	34	2500	33.3	75
Inland waterways	290	1.2	240	400	1.6	250	400	1.5	267
Oil pipelines	400	1.5	267	800	2.5	320	500	1.5	333
Regular R.R. freight	700	3.5	200	955	4.0	240	1350††	5.5	240
Intercity trucks	400	8.0	50	700	11.6	60	300	4.0	75
Rail piggyback	50	0.3	170	120	0.6	200	240	1.2	200
Air freight*	5	0.5	10	25	2.5	10	10	1.0	10
Intercity freight	1845	13.8	134	3100	22.8	136	2800	14.7	190
Utility, farming, etc.**	–	10.0	–	–	15.0	–	–	12.0	–
Transit bus and cabs	20	0.5	40	30	0.6	50	80	1.6	50
Rapid transit and RRS	12	0.2	60	18	0.3	60	70	1.0	70
Local and urban trucks	200	10.0	20	300	10.0	30	200	5.0	40
Urban gas autos	620	35.0	18	1000	50.0	20	450	16.3	27
Electric autos	–	–	–	50	2.0	40	300	6.0	50
Private aircraft	9	0.9	10	20	2.0	10	15	1.0	15
Urban and miscellaneous	861	56.6	15	1418	79.9	17	1115	42.9	26
Total United States transport†	3725	91.0	41	6998	159.1	44	6400	77.9	82

*Includes military freight.
**Repair, construction, service vehicles, farm equipment, military, etc.
†Excludes private planes, miscellaneous units, farm equipment, military, etc.
††Includes containers.

(Source: Reference C-7)

TABLE C.2-9

TRANSPORTATION/ENERGY DATA FOR INTRAURBAN SYSTEMS

MODE	BLOCK SPEED (mph)	AVERAGE FUEL CONSUMPTION (mpg)	PASSENGER LOADING		$\eta_{T/E}$ (PASSENGER-MILES / GALLON)	
			LOAD RANGE (pass/veh)	LOAD FACTOR (%)	Range	Average
A. Automobiles						
1. Luxury	5-20	12.5	1-6	28.3	13-75	21
2. Full Size	5-20	13.2	1-6	28.3	13-80	22
3. Intermediate	5-20	14.1	1-6	28.3	14-85	24
4. Compact	5-20	17.3	1-4	42.5	17-70	30
5. Subcompact	5-20	26.5	1-4	42.5	27-105	45
6. Diesel	5-20	24.0	1-5	34	24-120	40
B. Motorcycles	10-25	30-80	1	110	35-90	60
C. Bus Transit						
1. Full Size Diesel	5-15	4.1	41-53	45	75-100	90
2. Medium Size Diesel	5-15	5.5	25-33	45	60-80	70
3. Medium Size Gasoline	5-15	4.5	25-33	45	50-70	60
4. Full Size Rankine	5-15	0.6-1.1	41-53	45	10-25	18
5. Minibus Gasoline	5-15	7.2	15-25	45	50-80	65
6. Van Gasoline	5-15	9.0	6-10	45	25-40	32
D. Rail Transit						
1. Subway and Elevated	15-30	2.5	50-80	35	45-70	60
2. Surface Rail	15-25	3.0	50-70	35	50-75	65
3. Trolley Coach	10-25	3.2	40-60	35	45-70	55
E. Potential Future Systems						
1. Electric Auto	5-20	20-25	1-4	42.5	20-100	40
2. Stirling Bus	5-15	5-7	31	45	70-100	85
3. Rankine Bus	5-15	2.3-3.3	41-53	45	40-80	60
4. Personal Rapid Transit (PRT)	10-30	25-30	4-6	26-32	35-50	40

(Source: Reference C-7)

TABLE C.2-10

TRANSPORTATION/ENERGY DATA FOR INTERCITY SYSTEMS

MODE	BLOCK SPEED (mph)	AVERAGE FUEL CONSUMPTION (mpg)	PASSENGER LOADING		$\eta_{T/E}$ (PASSENGER-MILES / GALLON)	
			LOAD RANGE (pass/veh)	LOAD FACTOR (%)	Range	Average
A. Automobile						
1. Luxury	40-60	12.5	1-6	35	13-75	26
2. Full Size	40-60	13.2	1-6	35	13-79	28
3. Intermediate	40-60	14.1	1-6	35	14-85	30
4. Compact	40-60	17.3	1-4	53	17-69	36
5. Subcompact	40-60	26.5	1-4	53	27-106	56
6. Diesel	40-60	24.0	1-5	42	24-120	50
B. Buses						
1. Highway Coach Diesel	40-60	7.0	41-53	46	130-170	150
2. Highway Coach Gas Turbine	40-60	2.5	41-53	46	50-60	55
C. Rail						
1. Electric	50-70	2.5	70-125	37	65-115	90
2. Diesel	50-70	2.1	50-90	37	39-70	55
3. Gas Turbine	50-70	.5-.7	140-240	37	28-61	50
D. Air						
1. Short Range	200-300	.2-.4	75-150	50	10-30	15
2. Long Range	400-500	.2-.4	150-350	50	10-40	20
E. Potential Future Systems						
1. Gas Turbine Bus	50-70	4-5	41-53	50	80-130	105
2. Stirling Bus	50-70	5-7	41-53	50	100-190	140
3. TACV	100-250	.4-.5	60-120	63	15-40	30
4. TVS						
a. Pneumatic	100-300	1.1-1.9	60-120	55	35-125	80
b. Non-Pneumatic	100-300	.8-1.1	60-120	55	25-75	50
5. VTOL	125-200	.24-.37	50-100	55	7-20	15
6. STOL	125-200	.33	100	55	10-20	18

(Source: Reference C-7)

Stephens* provides the following data by A. Lewis Russell on storage tank security:

"Storage Tank Security is designed to minimize losses resulting from artillery, mortar, aerial, small arms or satchel-charge attack. Several defensive steps can be taken to accomplish this objective.

"The following details have been obtained from several sources. Tests and experience have proven the defense steps recommended below to be effective in minimizing losses resulting from attack.

"1. Blast Walls - Blast walls constructed around each individual storage tank have proven to be effective against shrapnel emanating from "near-miss explosions," small arms fire up to and including 57 and 75mm weapons with contact fuse detonation, satchel charges placed by saboteurs and mortars up to 81mm.

"It is recommended that blast walls be constructed of brick or hollow tile and mortar, with the brick or tile laid to give a wall about .25 meters thick. Reinforcing is used with vertical supports at 3-4 meter intervals around the periphery and horizontal reinforcing rings about 3 meters apart. The inner surface of the blast wall should be about 1.25 meters from the tank. (See attached drawing.) Experience has further indicated that the blast walls must have ventilation slits approximately .2 meters from ground level to avoid trapping gas fumes between wall and tank. These slits must be protected by heavy wire mesh to prevent hand grenades or other explosives from being introduced between the wall and tank foundation.

"A door of 1.25 cm. steel plate or 5 cm. wood sandwiched between 2-.6 cm. steel plates is recommended. The sill should be about .2 meters above the ground level and of masonry. It will serve to contain product in case of modest spills or leakage. A lock not easily forced or broken should be used to secure the door to minimize the possibility of forced entry.

"The masonry wall should rise about 1 meter above the tank top, to support mesh covers.

"2. Mesh Covers made of hardware cloth, lightweight up to 1/2" holes are used as nets over the tops of the tanks to cause incoming shells with contact fuses to explode at the screen, thus minimizing damage to the tank proper.

"Best protection is derived when the hardware cloth is placed in 2 layers about 10-15 cm. apart, about one meter above the tank top and anchored to a supporting truss. The truss work is secured to the top of the blast wall with screen supporting members welded to the top of the tank itself to support the weight of the layers of hardware cloth.

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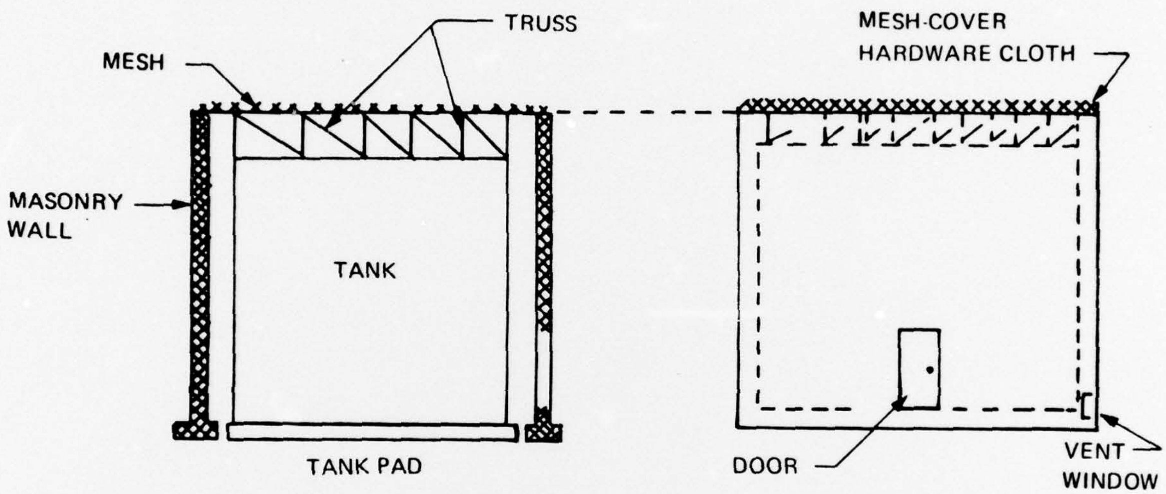
*Stephens, Maynard M., Vulnerability of Total Petroleum Systems, Office of Oil and Gas, U.S. Department of Interior for Defense Civil Preparedness Agency, Washington, D.C., May 1973, pages 141-142.

"3. Steel Access Doors in Blast Walls - Steel plate doors equipped with locks are recommended. They have proven to be effective against efforts by saboteurs to destroy storage tanks through the placement and explosion of satchel charges."

The sketch below is a rough plan for construction of blast walls around different types of tankage:



Tank Protection – Sides and Cover

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